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2nd ed

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A  
NARRATIVE OF THE BUILDING  
AND  
A DESCRIPTION OF THE CONSTRUCTION  
OF THE  
**EDYSTONE LIGHTHOUSE**  
WITH STONE:  
TO WHICH IS SUBJOINED,  
AN APPENDIX,  
GIVING SOME ACCOUNT OF  
THE LIGHTHOUSE ON THE SPURN POINT,  
BUILT UPON A SAND.  
BY JOHN SMEATON, CIVIL ENGINEER, F.R.S.



The MORNING after A STORM at S.W.

*See S. 2. 2. 3. 37 and Technical References.*

THE SECOND EDITION.

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FOR LONGMAN, HURST, REES, ORME, AND BROWN, PATERNOSTER-ROW.

1813.

*Edystone*





TO

## THE KING.

SIR,

FROM the ambition natural to man, all authors are desirous, that their works should be placed in the most favourable point of view. This motive alone would have urged me to solicit permission to lay mine at the feet of my Sovereign; a Sovereign whose reign has been marked by the most rapid and distinguished progress, in the arts, in commerce, and in the most sublime as well as the most useful discoveries, altogether arising from YOUR MAJESTY's immediate protection and encouragement.

To be allowed to approach YOUR MAJESTY, and mix my tribute with others of so much higher importance, is a most flattering distinction. It is further my particular felicity, that the tribute I offer is of such a nature as to accord with the scope of YOUR MAJESTY's private studies.

The very close manner in which the model of the Edystone Lighthouse was examined by YOUR MAJESTY, soon after the building itself was completed, has left the most lasting impression upon my mind, of the critical knowledge which YOUR MAJESTY has acquired in the art of building; and the earnest attention YOUR MAJESTY was then pleased to bestow upon the subject, has emboldened me, at this distant period, to present it once more to Your consideration.

It certainly requires an apology, that I have not more early acquitted myself of a work, that then seemed to engage YOUR MAJESTY's curiosity; the delay, however, as it has given me time to mature my thoughts, and has afforded proof of the stability of the structure, may possibly render the book more worthy of acceptance: and it will be a further excuse, that I can with truth say, I have ever since been employed in works, tending to the immediate benefit of YOUR MAJESTY's subjects; and indeed so unremittingly, that it is not without the greatest exertion, that I am enabled, even now, to complete the publication.

DEDICATION.

I have it not in my power to present YOUR MAJESTY with a fine piece of writing, or of drawing; neither literature, nor the fine arts, having been much the objects of my study; but I humbly submit to YOUR MAJESTY, a plain account of the construction of a plain and simple building, that has nevertheless been acknowledged to be, in itself, curious, difficult, and useful; and as such, I trust, worthy of observation.

I have the honour to be,

SIR,

YOUR MAJESTY'S

Most dutiful subject,

and most obedient servant,

J. SMEATON.



## P R E F A C E.

HAVING in some part or other of the following work delivered the whole of what I would wish to say relative to the building, the history, and the description of the Edystone Lighthouse, I have little to offer by way of Preface, but what regards myself; or, my reader.

WHEN I recommenced the composition of this work, in the year 1784; as I had then written several essays in the Philosophical Transactions, in which I had been happy enough to make myself understood; I did not suppose it a matter of difficulty to give a distinct account of the progress and structure of the Edystone Lighthouse. I considered the account of every operation as a separate essay; and conceived, that by joining them altogether, I should produce the book I meant to write. The motive to this undertaking will be found fully explained, in the latter part of the following Introduction; but the time it has taken, and the difficulties I have met with, have been, beyond all comparison, greater than I expected.

THE Introduction was the essay with which I began; but this Preface being written after every constituent part of the work is gone through, I now find reason to change my first opinion, and am convinced, that to write a book, tolerably well, is not a light or an easy matter; for, as I have proceeded in this work, I have been less satisfied with the execution. In truth I have found much more difficulty in writing, than I did in building; as well as a greater length of time, and application of mind, to be required. I am indeed now older by 35 years, than I was when I first entered upon the enterprise; and therefore my faculties are less active and vigorous; but when I consider that I have been employed full seven years, at every opportunity, in forwarding this book; having all the original draughts and materials, to go upon; and that the production of these original materials, as well as the building itself, were dispatched in half that time, I am almost tempted to subscribe to the sentiment adopted by Mr. POPE, that

*"Nature's chief Masterpiece is writing well."*—ROSCOMMON.

It is true that I have not been bred to literature, but it is equally true, that I was no more bred to mechanics; we must therefore conclude that the same mind, has, in reality, a much greater facility in some subjects, than in others. How I am to succeed as a writer, is yet to be tried, and I shall readily submit to the decision of the impartial Public. I can say with great truth, that I have taken much pains, and have left nothing undone, that appeared necessary to the full information of my reader upon the subject: and I hope, that however I may be defective otherwise, I have not fallen short of an explanation, to those whose leisure, and patience, may give them leave to go regularly through the detail.

AS it is not a kind of work, that I could expect to find interesting to many readers, I have printed but a small edition in point of number; which renders it necessary to lay a heavier tax upon the curiosity of those, who may be inclined to acquaint themselves with the subject, than I could have wished; at the same time, if the whole edition were sold, it will a good deal fall short of reimbursing my expences. Could I have published within four or five years of the completion of the Lighthouse, the performance was then so much talked of, that I should certainly have ventured to have printed a considerable impression; but the novelty having yearly worn off, down to the present time, the expectation must now be rated very low; especially if it be considered, that most part of my readers were then unborn: and, the greatest real praise of the edifice, being that nothing has happened to it, nothing has occurred to keep the talk of it alive. The public curiosity, therefore, will be with more difficulty excited afresh.

PERHAPS I ought to make an apology for the largeness and fineness of my paper, as an article apparently enhancing the expence.—When I have seen a set of fine prints, produced with great labour and cost, spoilt as representative pictures, by being folded into a book, I could not but much regret it: and, the expedient of binding up the prints into a separate book, while the letter-press matter is of a different size, I can only look upon as the necessary choice of two evils: for, I suppose it must be unhandy, and disagreeable, to have the book upon one shelf, and the prints belonging to it on another. On this account I intended from the beginning, to bring my prints within the compass of half a sheet of imperial paper, and to have the letter-press work of the same size\*, though the paper should be coarse.—I therefore made choice of a sample of an ordinary paper of the imperial size, and engaged my friend Mr. WHATMAN to make me the quantity; but he, willing to shew himself a patron of the work, gave me a paper of the best fabric, at the same price I must have paid for the coarse. To Mr. WHATMAN therefore my reader is obliged for the superior goodness of the paper.—I do not however mean to pass the supposition upon my reader, that the prints, I either meant, or have been able, to procure, are of that delicacy as in themselves to demand all the attention I have had towards them. They are in reality little more than geometrical lines, drawn to explain geometrical and mechanical subjects. If any of them puts on the appearance of any thing further, it is to render it more explanatory and descriptive. They are in reality not meant as pictures: but yet, if a right line or circle, is drawn upon paper, it will appear a right line or circle, if the paper is flat; but let that piece of flat paper be folded into one, two, or more angles, the natural appearance of the figures is destroyed; and figures, that are in themselves complex, are rendered still more so. By this treatment, good prints are in reality spoilt, and bad ones rendered still worse. I am therefore rather surprised, that the learned have not much attended to this matter.

AS I speak and even write a provincial language, and, as I have already mentioned, was not bred to letters, I am greatly obliged to my friends in the country†, for perusing and abundantly correcting my manuscript: and last of all, to my friend Dr. BLAGDEN, who has been so obliging as to overlook the greatest part of the printed proofs, with much advantage to the work. I say the greatest part; as in justice to him, I must observe, I was obliged to send several of the sheets to the press, without his seeing them. Whenever therefore a more than ordinary deficiency occurs in point of diction, my reader may conclude that sheet never went to Dr. BLAGDEN.

IF I am asked why, being so slenderly equipped as a writer, I set about it at all; and did not wholly commit it to some other person? My answer is, that I consider this, as of the nature of a commentary; and that in an executive matter of art, the artist must write for himself; as he only can feel the force of his subject, so as to give it energy. I do not apprehend it to be of the nature of a commentary that the style should be polished; only that it should explain the subject, in the most easy and familiar manner. If I have failed in this last respect, I have fallen short of my hopes and wishes.—It is possible some discordancies may be met with on a strict perusal, notwithstanding the care and pains I have bestowed.—As it is, I commit it to its fate; having no presage it will be used worse than it deserves.

\* One of my plates, indeed, somewhat exceeds the imperial in size; but that was not the case, when it was engraven, in the year 1762: which seems to shew, that the size of this paper is somewhat lessened since that time.

† Mr. WALTON, formerly my colleague in the Derwentwater Receivership: and after him the Reverend Mr. MICHELL, well known to the public.



# CONTENTS

## OF THE SEVERAL SECTIONS; BEING AN EPILOGUE OF THE WORK.

### INTRODUCTION.

Page 1. PHAROS the most celebrated lighthouse of antiquity. General description and dimensions. Size of its base uncertain. Distance at which it could be seen.—Compared by Josephus to the Phasael at Jerusalem.

P. 2. Apparent mistake of Josephus relative to the size of the Pharos. Reconciled. Pharos built by Sostratus. His inscription; by permission of Alexander according to Pliny.—Otherwise intimated by Lucian.—Lucian's invective adopted by modern historians; but rejected.—The reasons.

P. 3. The Pharos cost 800 talents. Their value uncertain. — Destroyed; the occasion and time uncertain; yet subsisting complete in the 12th century.—By Abulfeda's account, about 400 years ago, it was reduced in height; since then destroyed. Most probably by an earthquake. Subisted 1600 years.

P. 4. Other lighthouse towers have obtained the same appellation.—The Tour de Cordouan upon the French coast, the most remarkable of the modern ones.—Finished in 1610 by Lewis de Poix, a French architect. Built upon a bare rock 500 fathoms long and 250 broad. Liable in storms to a great surf. Its foundation described. — Surrounded by a circular wall. Not a place of defence.—Principal dimensions of its elevation. — Accommodation for the lightkeepers.

P. 5. Architecture highly finished. The rooms described in the first and second story.—Third story described.—Original lantern.

P. 6. Decoration of the King's apartment.—Different orders of architecture in the building. — Architect reproved, by Belidor, for using a profusion of ornaments. Vindicated. Lantern damaged by the original fires. Taken down and fire kindled below. Found there inadequate, and restored. The new lantern.

P. 7. Reflectors applied to the new lantern.—Edystone lighthouse an object of public curiosity. Awakened by the completion of the present building in 1759.—The model shown to their present Majesties and several of the Royal Family. — The author requested to publish an account of his proceedings.—His reason for complying therewith.

P. 8. Progress made in 1763. Reasons why discontinued till 1793.—Proposes beginning with a description of the rocks; and of the former buildings thereon.

### BOOK I.

#### CHAP. I.

#### CONTAINING A GENERAL ACCOUNT OF THE EDYSTONE ROCKS.

- §. 1. Rocks described as in nature independent of any building.
2. Name. Its probable origin.
3. Course of the tides.
4. Situation, with respect to the coast—to the Ramhead, the Start, and Lizard Points.
5. Situation respecting the Bay of Biscay, and the Atlantic Ocean.
6. The violence of the sea augmented on these rocks by their particular form and position.
7. Effect of the ground swell augmented by an upright face, naturally formed on the rock.
8. Further augmented by the particularity of the tide.
9. Flow of the tide upon the rock.
10. A rocky bottom extends considerably from the rocks, a cause of impediment in the mooring of a proper attendant vessel.
11. Component matter or substance. A peculiar species of laminated granite, in Cornwall called a killas.—Elastic.
12. General directions. Time and flow of the tides. Proper time of setting forward from Plymouth, for visiting the Edystone.

#### CHAP. II.

#### CONCERNING THE CONSTRUCTION OF THE LIGHTHOUSE UPON THE EDYSTONE, BUILT BY MR. WINSTANLEY.

- §. 13. A lighthouse upon the Edystone desirable.
14. First attempted by Mr. Winstanley.
15. Peculiarity of Winstanley's genius—prompted him not only to attempt difficult enterprises, but in a difficult mode.
16. Erections by Winstanley on the Edystone.
17. A narrative of the building, begun in 1696, and more than four years in hand.—Many difficulties, as the sea in calm weather would mount and fly more than 200 feet.

§. 18. The first summer spent in making twelve holes, and fixing twelve great irons into the rock.

19. The second summer in making a solid body or round pillar.

20. The third season, the pillar enlarged at its foundation, and the superstructure raised to 80 feet high. Lodged therein soon after. Midsummer.—Great distress by a storm. Finished the building and put up the light the 14th November 1698.

21. The fourth year, finding that in the winter the sea had buried the lantern at times, though above 60 feet high; he encompassed the former building with a new work, took down the upper part, and raised it to 120 feet high; and yet in time of storms the sea appeared to fly 100 feet higher than the vane.

22. Besides the narrative—Winstanley gives the situation of the lighthouse; and some account of the Edystone rocks.

23. A further account of the rocks and of the tides.

24. An orthographic elevation from Winstanley's perspective.

25. Great merit in Winstanley not only to undertake but achieve what had been generally deemed impracticable. An anecdote.

26. In 1703 repairs wanted, and Mr. Winstanley went off to superintend the same.—An anecdote.—A violent storm arose, the lighthouse and all therein perished.

27. Extracts from a book intitled the *Sronx*.—Describes the loss of the lighthouse, and of Mr. Winstanley.—The model of it in Essex broke to pieces at that time.—A Virginia ship lost soon after.

#### CHAP. III.

#### ACCOUNT OF THE SECOND LIGHTHOUSE BUILT ON THE EDYSTONE BY MR. RUDYERD.

§. 28. The great utility of Winstanley's lighthouse.—Desirable to have one there. Not impracticable.—An act passed in 1709, and the work begun the same year.

29. The privilege and duties vested in the corporation of the Trinity House, Deptford Strand. A term granted to Captain Lovett.

30. Captain Lovel engaged Mr. John Rudyerd to be his engineer, then a silk mercer on Ludgate Hill, assisted by Mr. Smith and Mr. Norcott, shipwrights.—Mr. Rudyerd endeavoured to avoid the errors of his predecessor, by aiming at simplicity.

31. Mr. Rudyerd completed his design and published a print with explanations.

32. An orthographic elevation from the print.

33. Mr. Rudyerd did not distinguish himself by any after-work. The print seems taken from some previous drawing.

34. Mr. Rudyerd's description of the situation, and general construction of his building.—The upright timbers described as composing the outside shell, different from the real number.

35. Proposes cutting the inclined surface of the rock into steps—executed imperfectly.

36. Method of forming dovetail holes for fixing his iron branches.

37. Method of running in those iron branches with lead.

38. Method of establishing a solid basement of wood. Situation of the branches.—In number 36.

39. Method of keying and fixing the branches. A material improvement. Winstanley's less perfect.

40. Rudyerd, besides the fastenings of his timber work described, applied the great principle; weight is most effectually resisted by weight.

41. Strata or courses of Cornish moorstone inlaid

42. Tonnage of the stone; and description of the courses of wood. Particular courses furnished with compass timbers.—Places of the compass timbers. Well-hole for the stairs described.

Reference to the plans of the moorstone courses. Upright bars.

43. The ascent to Rudyerd's entry door by an iron ladder

44. Well-hole for the stairs and passage in the 2d set of moorstone courses. Their tonnage.—3d set of moorstone courses. Their tonnage. Timber courses up to the store room floor.

45. Height of the store room floor. From the rock to this floor, denominated the solid.

46. Floor of Rudyerd's store room as high as Winstanley's state room; regulated by the height of the unbroken waves.

47. Application of the upright bars. The connection after.

48. Mode of building the rooms above the solid to the balcony floor.

49. The main column a simple frustum of a cone. General dimensions

50. Method of joining the upright timbers by scarfs. The dimensions. Caulked with calum.—The sole a piece of shipwright's; the moorstone considered as ballast. Its tonnage.

51. The windows and doors, like the port-holes of ships. Two

projecting parts beyond the frustum; the cornice at top—and the keut at bottom.

52. Description and dimensions of the lantern; and height of the light.—Height and base of this lighthouse.

53. The rock represented in the plate as it appeared in 1756; and the building, as it stood previous to its demolition in 1755.—Technical description.

54. Use of the helicon and rails.—No cranes used as in Winstanley's.—The chink in the rock pointed out, where one of Winstanley's crane chains was jambed fast in the storm of 1703.

55. Useful instructions to engineers to be drawn from this building.

56. Temporary light fixed by Rudyerd. The manner of it.—The building finished in 1709.

57. Anecdote that arose in the course of this building.—Behaviour of Lewis XIV.

58. Account of materials used in the construction of this building.

#### CHAP. IV.

CONTAINING SUCCEEDING TRANSACTIONS AND OCCURRENCES FROM FINISHING MR. RUDYERD'S LIGHTHOUSE TO THE TOTAL DEMOLITION THEREOF.

59. About 1715, Captain Lovel being deceased, his property therein sold, and purchased by Messrs. Weston, Noyes, and Cheetham, in 1744 tore away 50 pieces of the uprights.

60. House needed no material repairs till 1723. Worms then discovered in the timbers. Mr. Holland appointed to make the necessary repairs.

61. Experiments on sheathing the timbers with copper, &c.—Found not fully to answer.

62. Storm in 1744 tore away 50 pieces of the uprights. Repaired by Mr. Jessop.—Mr. Holland promoted to be King's builder at Deptford, recommended Mr. Jessop.

63. The house attended originally by two men, a difficulty arose. Afterwards attended by three.—This furnished a seasonable relief.

64. Anecdote of lightkeepers living together without speaking. Anecdote of a man's commencing lightkeeper to avoid confinement.

65. Fatal catastrophe of this building. Recital of particulars.

66. How the building caught fire, not certainly known; but began in the cupola.—The author's conjectures. Began 31 December at two in the morn.; one of the lightkeepers exerted himself to quench the fire. Frustrated by want of water. Singular instance of receiving melted lead into his stomach.

67. The fire seen from the shore, and a fishing boat sent off by Mr. Edwards.—The men found retreated to the cave in the rock, to save themselves from the falling fire.

68. Landing on the rock impracticable. Contrivance to take off the men. One of them ran away as soon as landed.—The sufferer by the lead sent home to be taken care of.

69. Efforts of Mr. Tolcher, collector of the light duties, and his son. Landing impracticable. The fire communicating itself to the solid, and not likely to be stopped there.

70. Admiral West, commander of the fleet in Plymouth Sound, sent out a boat with an engine, and attended by Mr. Jessop the surveyor. Remarkable incident to the boat.—The engine broke, and further attempts baffled.

71. The only remaining hopes from a change of the wind. Reasons why.—Became one great body of red hot matter. Burnt for five days.

72. Henry Hall, who had received the lead, put under the care of an eminent surgeon, for some days grew better, taking his medicines and swallowed other things; but died on the 12th.—On opening the stomach, a piece of solid lead was taken out.

73. An account of the case transmitted by the surgeon to the Royal Society. At first disbelieved.—Experiments on animals, tried by the surgeon, in support of his character. Animals found to sustain the operation—These experiments corroborated by the testimony of others.—The surgeon censured for cruelty to animals.—Vindicated.

74. Suggestions of some, how some part of the building might have been saved. The expedient in the author's opinion could not have been successful; nor any other practicable.—Nothing, as it would seem, could have saved it, but a storm.—Its duration 49 years.

#### BOOK II.

AN ACCOUNT OF PREPARATORY MATTERS TOWARDS BUILDING THE PRESENT LIGHTHOUSE UPON THE EDYSTONE ROCK, WITH STONE.

#### CHAP. I.

CONTAINING THE PROCEEDINGS FROM THE DESTRUCTION OF MR. RUDYERD'S LIGHTHOUSE IN DECEMBER 1755, TO MR. SMEATON'S DEPARTURE FROM LONDON TO PLYMOUTH, IN MARCH 1756.

75. The proprietors having the remainder of a term of more than half a century, strenuously apply themselves towards rebuilding. Difficulties arose and stated. An act to empower

Mrs. Hostlegger to sell part of her property. Three eighth shares represented by the Westons. A fortunate circumstance.—Considered it not as a work for a general undertaker in the building way; but for some one of a natural mechanic genius.

76. Mr. Weston considered the Royal Society as likely to furnish or recommend a proper person. Applied to Lord Maclesfield, then president; who recommended the author. Then in the country, and unknown to Mr. Weston.—Pointed out a friend to write to him.—The author wrote to by Mr. B. Wilson, that he was made choice of to rebuild the Edystone lighthouse. The author conceiving this building to have been of stone, could not imagine it could be totally destroyed by fire.—Desired further information. Answered, that it was a total demolition; and he was absolutely chosen to this work.

77. Returns to London. An interview with Mr. Weston; papers, plans, and models of the late structure explained by Mr. Weston.—Great bias in favour of the old building. A question suggested. Answered satisfactorily.

78. The plans and models being sent to the author, were attentively considered. Not sufficient to make out the precise plan of any of the preceding architects. Had been compiled from occasional observations.—Hence led to consider those pre-conceptions the author had formed, of its being a stone structure. An interview desired with the body of the proprietors upon a leading question.

79. The author states the advantages of a stone building. The proprietors the certainty of success in one of the same structure as the last. Universally believed the safety of the late building was owing to its complacency.—The objections answered; and reduced to a simple question.—Determined in a satisfactory manner.

80. The author's reasoning, on the difference in structure of stone and wood. An enlargement of the base very eligible.

81. The figure of the bole of an oak furnished an idea. Reasoning upon its figure. The column of greatest stability.—References to a figure.

82. Bond of the stone to the rock, and to one another.—Cramping considered. Objections. Of great consequence, by all possible means, to save time upon the rock.—Dovetailing considered. Sparingly practised in masonry. An idea, taken from a method sometimes practised, of fixing the kirk of the walking paths in London streets.—Sketch of the method.—An example from Belidor of a sort of upright dovetail stones, in the floor of the great sluice at Cherbourg.—The idea of dovetailing matured.

83. Fair section made out for a stone building.—The sloping of the rock advantageous to the strength of the foundation.

84. Another interview proposed with the proprietors.—On exhibiting those original sketches, they declared their entire satisfaction; and proposed they might be shewn to the proper boards; and, if they approved, to prepare for execution.—In the author's opinion, matters not ripe for this. He ought to see the rock, and take real dimensions, to enable him to make a working model. Approved by the proprietors; and that it should have the same general form and conveniences as the last.

#### CHAP. II.

CONTAINING AN ACCOUNT OF THE PROCEEDINGS AND OCCURRENCES ON MR. SMEATON'S FIRST JOURNEY TO PLYMOUTH, IN THE SPRING OF THE YEAR 1756.

85. Arrival at Plymouth. Interview with Mr. Jessop, who appeared likely to answer the character the author had had of him.—Openings of his proposal of a stone building, and Mr. Jessop's objections.—The late house in a state of decay by the worms.

86. Wind not favourable to go out to the rock. Waited on Commissioner Rogers. Directs artificers to make tools for trial of the rock.

87. The 2d of April sailed out near the rock. Viewed it, but could not land.

88. 2d voyage, April the 5th. Landed and staid 2½ hours. General observations.—Traces of Winstanley's irons. Observations on Rudyerd's iron branches and steps.—Upper part of the rock damaged by the fire.—Tried the workableness of the rock.

89. No appearance of impracticability of a stone building. A more safe and certain way of landing highly desirable.—Often difficult, after a vessel had delivered her cargo, to get out again from the Gut.—An attending vessel in company, necessary.

90. April 9th. Wind favourable, went out at midnight, but obliged to return.—No prospect of success at sea till the 14th.—Looked out for a work-yard. Its necessary properties.—No place to be had in or about Plymouth.—Embarcadero the work-yard used by Rudyerd; not suitable to a stone building.—Mill Bay the most likely situation.

91. Excursion to see the moorstone at Hingstone Downs. Manner of working it.—Price.—Rendered low by the regularity of its splitting.

92. April 14th. The 4th voyage proved unfavourable to land. An hard gale; bore away to the harbour of Fowey.—This harbour described.—Mistakes concerning it.—Fowey, or Foy harbour the key of the Edystone service.

93. Went to Lantivity. Found Walter Treleven, who wrought moorstone for Rudyerd. Described the manner. The moorstone here different from that of Hingstone Downs, and more



suitable to the author's purpose. Manner of its carriage by land.

94. Blew hard till 19th. Went out the 5th time for Edystone. A calm; anchored 4 miles from it, succeeded by an hard gale, and with difficulty regained Plymouth.—Hence the expediency of a store vessel to be moored near the rock appeared to the author. Approved by Mr. Jessop, who recommended a particular construction for that purpose. If a floating light was moored there, it might answer both purposes.

95. A piece of Portland stone cut out of the King's dock, that had been perforated by a kind of small shell-fish; like wood with the worms.—Pieces of marble rock found to be perforated in a similar manner. Portland stone not eligible for the outside of the lower works of the Edystone.—This stone likely to last longer than wood; but the author's ideas not confined to an age or two.—Those perforations chiefly confined to low water mark. Unnecessary to run any risk, moorstone being undeniable.

96. April 22. The 6th voyage. Landed on the rock before 6 morn. Staid till noon. Operations interrupted by the ground swell. Relanded at 2, and staid till 9 at night.—Boat laid in the Gut all night. Next morn landed at 5, and went on till 11. Obligated to retreat by a ground swell, which was succeeded by an hard gale of wind. Observations on its effects till 5; then returned.

97. Account of the operations on the rock. Instrument for taking certain points of the rock.—Construction and use of the instrument.—Improvements in this apparatus.—Thirty-five primary points herewith determined. Manner in which many more were deduced from those originals. The measures hence deduced laid down to a scale.

98. The 7th voyage unsuccessful in landing. Bore away to Falmouth.—Excursion from thence to Constantine. Interview with Mr. Box a moorstone worker there.—A capital workman, but had chiefly applied to small works.—Author determined to use Portland stone for the inside works; and on account of the difficulties of carriage, to reduce the size first intended of the granite pieces.—Returned by way of the Edystone; not landing, returned to Plymouth.

99. Report of 40 fish prize ships in Plymouth, to be sunk near the Edystone.—The weather appearing favourable, the author proceeded to sea; but this attempt rendered fruitless, by a change of weather. On return waited on the commissioner; and re-monstrated against this measure: he proposed to consult Adm. Mostyn, who commanded at Plymouth. Delays dangerous. The author wrote to a proprietor, who applied to the Admiralty to give other orders. Next day saw Adm. Mostyn, who then relieved him from his apprehensions.

100. Weather bad till May 14. The author in this interval turned his thoughts on the subject of facilitating the landing; and on the proper mode of carrying on the works upon the rock.—An expedient described by Mr. Jessop.—Mr. Jessop a man of judgment, but not of invention.—Approved the author's plan. Substance of letters to the proprietors thereupon.

101. A stone building consisting of a greater tonnage, would take more time than if of wood. Ineligible to take a greater time in the whole than formerly. Expedition must therefore be procured by art. The means pointed out.—Further means. A store vessel and two sets of workmen.—Mode of payment, such as to make it their interest to do their best.—Plan for carrying on the works, and management of the workmen.

102. May 11th, the 9th voyage commenced. Practicable, but hazardous, to go into the Gut.—The author considers how to remedy this inconvenience.—To level the Sugar Loaf rock, in itself a great work. The use of transport buoys and a windlass of a new contrivance\* seemed applicable.—Approved by Mr. Jessop, who suggested improvements.

103. Landed at 7 morn, and staid till 11; obliged to quit on account of rain; but the most material measures now obtained.

104. May 13th, the 10th voyage, landed at 11 A.M. Quitted at 2½ A. All observations now completed.

#### CHAP. III.

CONTAINING TRANSACTIONS AND OCCURRENCES DURING THE AUTHOR'S RETURN FROM PLYMOUTH TO LONDON, IN MAY 1756.

§. 105. The author in his return to London visited the quarries that were likely to furnish freestone to Plymouth.

106. The quarries at Beare in Devonshire. Account thereof. Visited Portland. Recommended to Mr. Roper, agent at Portland for . . . Tucker, Esq. of Weymouth.

108. First object of curiosity the Portland quarries. Description of the strata.—The Portland cap.—Manner of working the merchantable beds into blocks for sale.

109. Description of the carriages for the stone, and method of using them.

110. The best freestone to be had here, in any quantity, rough scappelled, but not hewn.

111. The pier for shipping adjoining to Weymouth Road.—Portland lighthouses visited.—The strata of this island, various, and curious to the naturalist. The most striking curiosity to the author was the Portland beach. Renders it doubtful whether Portland is properly an island. The beach described.—Seemed to the author not to have had its origin at a very remote period.—Loose in its component parts, but not shifting; and rests on a blue clay.

§. 112. The author not having met with a full account of the beach, was willing to give such a one, as the time employed on this visit would allow; to excite the able naturalist to a more full investigation. A singularity obtains in the manners and customs of the Portland quarrymen.

113. Settled with Mr. Roper and determined; the best mode would be to send moulds to direct the scappelling. Proceeded to view the quarries at Purbeck.

114. The peninsula commonly called the Island of Purbeck. Corf Castle. The mortar examined.

115. Swanage the principal town. The quarries viewed, and the strata described.—Manner of working them. Strata of marble raised here; such as seen in many of our old cathedrals. The paving stone from hence having for many years past supplied the London markets wholly; now come at with more difficulty.

116. Strata called Purbeck Portland; quarries chiefly near St. Alban's Head. Manner of working, and qualities.—Departed from hence to London.

#### CHAP. IV.

CONTAINING TRANSACTIONS IN LONDON, AFTER THE AUTHOR'S FIRST JOURNEY TO PLYMOUTH.

§. 117. The author attended the proprietors. Account of proceedings, as already related. The leading question, whether to rebuild with stone entirely, or entirely with timber; or partly with both. Time, a principal consideration; that stated as relative to the different modes. An estimate not practicable for the whole business; as the greatest part of it would be widely open to accidents. But whichever mode the proprietors chose, the author would endeavour to perform in the most substantial manner and at the least possible expence.

118. Unanimously determined to rebuild with stone; and in the very best manner. Reasons for waving their own immediate interest, in this determination.

119. The author could not think himself justified in suppressing these reasons.

120. A stone building being resolved upon; the author was directed without loss of time to prepare such models and designs, as should fully explain the proposition to themselves; and to those boards, they should think it right to consult. The time and means left to the author.

121. Good effect of leaving him unfettered.—Main object to digest such a scheme as should go progressively on, according to opportunities, without derangements. With this view, having got sufficient dimensions, applied himself to the making an accurate model of the rock. The time spent in a mature digestion, likely to be more than saved by avoiding unnecessary work.—A first principle, to cut the rock as little as could be helped. For this end a second model was necessary, to shew the manner of applying the new work thereto.—The author determined to make both these models with his own hands.

122. His reasons, for executing these models himself.—In other matters he availed himself of the hands of others. The purchase tackle.

123. Viewed the Neptune buss, then fitting out for a floating light; chiefly to judge whether applicable as a store vessel, in the building service. Description of her.—Observed that if situated in a certain position she might answer that double purpose.—Declaration of a proprietor thereon.

124. The 13th July, the two models executed by the author exhibited to the proprietors.

125. Being fully considered, by the proprietors, they declared their entire approbation of the whole of the author's proposition; and desired him to explain the scheme to the Admiralty and Trinity House; and adjourned their meeting to the 17th, in expectation of those exhibitions being over.—The Board of Admiralty appointed the 15th, when the author attended, and met with their thorough approbation of his scheme.—The 17th no appointment received from the Trinity House; and the season fast advancing, the proprietors determined the author should set out for Plymouth on Monday morning the 19th of July.

126. During this absence from Plymouth a constant correspondence with Mr. Jessop. Final instructions from the proprietors.—One of the proprietors delegated their agent, in corresponding with the author; and managing affairs.

127. The author set out according to appointment for Plymouth.

128. The original designs and models, except that of the rock as the author found it, differ from the building, as it now stands executed; yet is sufficient to explain the mode of the building. Concise explanation of several plates.

#### BOOK III.

CONTAINING AN ACCOUNT OF PROCEEDINGS FROM THE COMMENCEMENT OF THE WORK UPON THE ROCK IN 1756, TO THE BEGINNING OF THE SECOND SEASON IN JUNE 1757.

#### CHAP. I.

NARRATIVE OF THE PROGRESS OF THE WORK DONE UPON THE EDYSTONE, FROM (THE AUTHOR'S) ARRIVAL AT PLYMOUTH IN JULY 1756 TO THE TIME OF MOORING THE NEPTUNE BUSS.

§. 129. Arrival at Plymouth, 23d July 1756. Met Mr. Roper at Dorchester. Found Hancock's sloop and other vessels pro-

\* Author finds, in 1759, that windlasses on this principle have been used in the Severn barges time immemorial.

## CONTENTS.

perly prepared by Mr. Jessop.—Neptune buss arrived, and lay in Stonehouse Creek. Not likely to be applied to the use intended. Sloop got ready for temporary service. Weather now unsuitable, and had been so for some time past.

§. 130. Weather still unfavourable till 3d August. Mr. Thomas Richardson appointed foreman of one of the companies. William Hill of the other. Mr. Jessop, general assistant. Wages settled.—Mr. Delacombe agreed with for half an acre of ground for a work-yard at Mill Bay. Mr. Harrison arrived as clerk to the works.

131. The 3d August was rowed to the rock in the yawl, and began to fix the center, and lines of the work. After which, obliged to return with the sloop to Cawsand Bay. The weather becoming more unfavourable, returned to Plymouth.

132. The 3th, went out again, came to an anchor, and attempted to moor the sloop, but obliged to desist.—The company landed and worked four hours with good effect.—The 6th, worked both morning's and evening's tide. Got nearly the whole of the work laid out.

133. Reasons for not using gunpowder in performing this work. 134. The 7th being Saturday, the companies changed upon the rock. The lues on the rock completed. Distribution of the semen.

135. Settled weather attended with land and sea breezes. The advantage thereof.

136. The work pursued without interruption till the 15th of August.

137. Cable found greatly damaged by the sharpness of the rocks at bottom. Place of the moorings shifted.

138. The 13th August, vessel fitted out by the Trinity House as a floating light, exhibited the same. The ground cable again cut by the rocks. One-third of the work of this season now dispatched. Extraordinary wages made last week, by the favourable weather. Position of the floating light. Judged two miles to the westward of the rock. Of no use to the artificers, unless to shelter them when driven westward, by distress of weather.

139. Sunday the 15th, a rough sea obliged the hands to slip their moorings and bring the sloop into Cawsand Bay. Returned on Tuesday morn, but weather still unfavourable. This day the 1st draughts for stone sent to Portland. This afternoon the sloop came again into Cawsand Bay. Lay there till Thursday. Then again went out, but obliged to return. Companies changed in Cawsand Bay.—Hill's company attempted to go out, but obliged to put back. Sunday got out; laid hold of the moorings, and landed; but after half an hour obliged to quit.—Next night the sloop's ground cable being again cut, obliged to go into Cawsand Bay.

140. The author next day received order from the proprietors to make use of the Neptune buss. Adapted her to the service with little alteration. The 27th, wind and weather moderate, Hill and Co. again went out in the sloop. The buoys being gone, they came to an anchor. Enabled to make short tides. The moorings recovered by sweeping. Sloop again moored. August 29th, buss cleared of unnecessary stores, and made ready. Wind, though moderate, unfavourable for carrying out the buss. Richardson's company rowed out in the yawl and changed upon the rock.

141. 31st. Buss brought out of Stonehouse Creek. Warped to one of the King's buoys in Hamoaze. Sept. 1st, wind not in favour, endeavoured to make a tack, but the vessel would not stay. Came to an anchor. Next day wind fair; but being moderate, and the buss an heavy sailer, made but little way. Came to an anchor in the evening 24 miles from the rock. Dispatched sharp tools to the company at work. Friday 3d, got the vessel out and were assisted by Richardson's company in warping her to her berth; proceeded to moor.

142. The chain moorings described. Mode of mooring as originally intended. A necessary alteration in the mode.

143. Manner of laying down the moorings described. Safe completion of this business.

144. September 4th. Work examined, and judged one half, for this season, to be completed.—The sloop brought home.

## CHAP. II.

### SEQUEL OF THE OPERATIONS UPON THE ROCK, OF THE FIRST SEASON OF 1756.

§. 145. The buss being satisfactorily moored; nothing now to hinder but bad weather. Draughts sent to Portland for the foundation courses.

146. Companies worked regular tides from 27th August to 14th September. Manner of preparing wooden moulds for the exact cutting of the stones.—Moulds necessary to every different size and shape of stone.

147. A West India ship and a man of war's tender saved from driving upon the N. E. rock.—Manner of splitting stones by the key and feather. Winstanley's chain released.

148. Sept. 14th and 15th, an hard gale at S.W. The first since the buss was moored, and was found to ride perfectly easy. The work examined by the author and the state of it described.

149. Unsettled weather. Work further examined. Difference of level of the foundation courses. The yawl having parted her grappling rope, and lost her grappling in endeavouring to weigh it; occasioned the expedient of the transport buoy, before suggested, to be put in use.

150. The 2d Oct. an hard gale of wind brought Richardson and Co. home in the yawl, having no sharp tools. Hill and Co. prevented going out.—The 8th, the seamen wanting provisions,

and the weather continuing bad, came home in the little yawl, with an oar for a mast and a blanket for a sail. This evening Hill and Co. got out.

§. 151. The season far advanced. The author forms a scheme to avoid weighing the buss's chain moorings.—Approved by Mr. Jessop, who suggests improvements.

152. The 13th, the great yawl broke adrift in a hard gale of wind.—Only 231 hours worked in October. Little wanting but levelling.—Clinch of the cable damaged by the rocks, and repaired.

153. Nothing to hinder the commencement of setting the stone foundation next season. Richardson ordered to return at the end of their week, though they were not relieved by the other company. Instance of great difference of the weather at Edystone and at Plymouth. Both buoys of the mooring anchors broke loose.

154. Machinery, &c. of the work-yard got ready for use. Experiments on the strength of the tackle.

155. A better appearance of weather in November. Hill's company went out. The author went off with a carpenter, &c. to make wooden moulds from the rock. Prevented by weather. Having landed, reports the state of the works.

156. The 12th Nov. the buoy chain completed. Experiment of its strength. Edystone boat sent out with provision; but returned without being able to get out. Attempted again the 15th without success; and this evening the buss arrived in Mill Bay. Since Oct. 2, the work had amounted only to 331 hours.

157. Buss's bottom become very foul, was cleaned, and again prepared for sea.

158. The author with proper assistants sailed the 21st November. Retarded by an accident; and the slow sailing of the buss even when clear.—Bridle cable being hard laid, and stiff by the water, came in very tardily. Somewhat damaged by the rocks. The 22d at 8 morning, the swivel got above water; and the buoy chain attached thereto. The fore lock clinched by the author. Fresh of wind obliged the Edystone boat to go home. Circumstances hindered the quitting the moorings till 3 A.

159. The wind become unfair for Plymouth, steered for Fowey.

Night dark and stormy, missed the harbour. Breakers ahead. By great exertion the vessel got about. Heaved down by stress of wind, gunnel frequently under water. Company in great jeopardy. Concluded to stand out to sea. Escaped the rocks, but split their sails, the main sail excepted.

160. Tuesday, 23d, at break of day, obliged to cut the only remaining yawl adrift. Wore the vessel and stood in for the land; which saw about noon, and judged the Lizard. Discerned land right ahead, which proved the Land's End, but upon the weather how. Evening more moderate, bent fresh sails, and made an attempt to get into Mounts Bay. Stew off the land during the night; and at two on Wednesday morning wore the vessel. Saw land soon after day-light, which proved the Land's End, still more to windward than the day before. Came to an anchor. Wind fresh right from the land. A consultation on measures. Resolved to attempt to make Scilly.

161. Saw a vessel from the east, which bore down upon them, and proved to be the White Hart of Pool, bound for Guinea. Could get no relief from her; but learnt the course for Scilly. Prepared for sailing for those islands, very early the next morning.

162. Thursday 25th, at two morning, began to heave in the cable; while doing, the wind ceased, and a breeze in favour sprang up, which enabled the company to steer for Plymouth.—At four on Friday morning abreast of Ram Head, and at six at an anchor in Plymouth Sound.

163. The relation of the work of the season completed. Concludes with the commendation of a deserving seaman. Safety of the vessel and company, in the late adventure, principally due to the activity and alertness of John Bowden.

## CHAP. III.

### CONTAINING THE TRANSACTIONS OF THE WINTER OF 1756, AND OF THE FOLLOWING SPRING 1757, TO THE COMMENCEMENT OF THE OUTWORK OF THE ENSUING SEASON.

§. 164. The most interesting facts related, without strictly confining to time. Mr. William Tyrell chosen foreman of the work-yard.

165. General design and contrivance of the work-yard explained.—Proper to use as large stones as the situation and service would admit.

166. Modern buildings in general composed of stones rather small than large. The reason thereof. Advantages of large pieces.

167. The size of stones most proper for the Edystone work pointed out.—Stones of a ton and upwards, not to be managed in the work-yard without machinery; or an increase of labour.—Reasons for trying every course to its neighbour.

168. Vessels arrived with stone from Portland in December 1756. The masons began to work. Difficulty in getting the moorstone brought home on account of its size. Dispatched a vessel from Plymouth with proper tackle.

169. Moorstone though hard yet friable, and difficult to bring to an axis. Necessary to do the principal part of the work at home. Mode of agreement for doing a certain part in the country. The prices agreed for.—Reasons for employing more than one contractor.

170. Construction of additional vessels necessary for the service of the ensuing year. The service best performed by small vessels.—Size of vessels pointed out.—The number.



§. 171. Yawls: the sort pointed out.—A large yawl purchased. The smaller made at home. Why to be preferred for the Edystone service, to those made at Deal. Drawing of a yawl preserved; and referred to; and the larger boats described, which answered the service.

172. The importance of obtaining cement, the most perfect that it was possible to make. Nothing of the resinous or oily kind could possibly answer in this situation. Only such as would become hard, without being ever dry.

173. The author resolves to winter at Plymouth, and go through a course of experiments on cements.

174. A journey to the west, the spring of the year 1757. The church of Lostwithiel viewed, that had suffered much by lightning. Its damages described.

175. The author went out to the Edystone to get the moulds made of the work upon the rock. Viewed the work, but could not land. The moorings in good order.—Several other attempts; but could not land till 25th April. The moulds then got in part made; but hindered from proceeding by a neglect of the carpenter. Completed on the 30th.

176. The work of the moulds for the foundation rendered inconvenient by being denied the use of the public rooms.

177. Much hindrance last season by our seamen being frequently detained by the men of war's cutters to impress seamen. The author suggests a remedy.

178. The vessels from Portland with stone for the Edystone, detained by fear of French privateers; and an order from the Admiralty for a convoy obtained thereupon.

179. The stone in Mill Bay work-yard being all wrought up, masons employed in quarrying marble for cubes for inlaying between the courses. The tinnies employed in boring holes through the stones for trepanning them down. 300 trenails purchased.

180. A combination among the workmen, and William Hill, one of the foremen of the rock companies, discharged.

181. The premium per hour given the last season proposed to be reduced; agreed to by the workmen.

182. The commanding officer of the fleet at Portsmouth being applied to, for a convoy for the stone from Portland; regular answers were received, yet no convoy ever attended this service.

183. Five fathom of large chain for the moorings arrived from London in May. Prepared to begin the work of the season, as soon as weather permitted; but previous to the relation of it, the author proposes to give an account of his experiments on cement.

#### CHAP. IV.

##### CONTAINING EXPERIMENTS TO ASCERTAIN A COMPLETE COMPOSITION FOR WATER CEMENTS, WITH THEIR RESULTS.

§. 184. The common tarras composition recognized. Some assertions of workmen concerning mortar unsupported.—Salt-water by them disapproved. The author's reasoning thereupon.

185. Enquiry into the effect of limes being imperfectly burnt. Great waste hereby in works at large; but did not hinder the author's experiments.

186. Method of making mortar for trials.

187. Common lime and sand would not stand the water test.

Question 1st. Concerning lime from stones of different hardness.—The investigation. Comparison of chalk lime with that of Plymouth marble.

Quest. 2d. Concerning the difference of salt and fresh water for making water mortar. The investigation.

Quest. 3d. Difference resulting from different qualities of limestone.—Investigation. That of Aberthaw in Wales approved.

188. The notion of workmen examined concerning repeated beatings of mortar.

Quest. 4th. If tarras mortar is better by repeated beatings. Investigation with Aberthaw lime.

189. Shell lime for water building examined.

190. Plaster of Paris for water building examined.

191. Lime of Bridstow in Devonshire examined.

192. Chemical examination of limestones proposed.

193. Method of the chemical analysis of limestones.

194. Trial of white chalk, Plymouth marble, and plaster. Aberthaw limestone tried, and also Bridstow.

195. Pure limes not the best for water building. The best generally contain clay.

196. Tarras, its properties recounted, and not answerable where subject to become dry.

197. Another property of tarras unfavourable for some uses. Terra puzzolana recommended by Belidor, and some procured for trial.

198. Puzzolana tried and approved; and best with Aberthaw lime.

199. The best method of making grout, or liquid mortar, necessary to be known; and proposed to be examined.

200. Investigation of the best method of making grout.—Plaster for this purpose tried and rejected.

201. Some account of tarras and puzzolana.—Method of the preparation of tarras in Holland for use.

202. Puzzolana described. In great quantities near Mount Vesuvius. That used for the Edystone from Civita Vecchia. That from Naples of an inferior quality.

203. Tarras and puzzolana agreeing in several obvious properties, other similar substances tried, but without success.

204. Composition of Edystone mortar being determined; enquiry how and where to procure the lime. That of Watchet re-

commended; to which place the author determined to take a journey.

§. 205. Journey to Watchet. Saw specimens of work done with that lime, and that of Aberthaw.

206. Watchet pier satisfactory as to the mortar work. Manner in which the strata of lias stone lie. Those used for burning into lime are got from the sea shore.—Then but little demand for this lime, and the reason. A quantity burnt to ascertain the bulk and weight. The mode of package agreed upon and described.

207. Blue lias stone of Watchet described; white lias analysed. Unfit for water works.

208. Author proposes an account of what has occurred to him on this subject since.

#### LIMES SINCE EXAMINED.

209. That of Barrow in Leicestershire.

210. White lias of Somersetshire compared with clunch lime of Sussex; a species of chalk described, containing clay, and good for water building. The lime of Darking in Surrey esteemed of the same kind.

211. Sutton lime of Lancashire. The stone analysed and described. Good for water building.

212. Gray lime of Berrinton near Petersfield, Hampshire, a chalk lime containing clay, like the clunch. A water lime.—A water lime of the chalk kind also near Guildford.

Blue lias limestone at Lyme in Dorsetshire, also esteemed good water lime.—Table containing the results of water limestones analysed.

213. Trials for a succedaneum for tarras or puzzolana; smith's forge scales found equal in quality, but not to be had in quantity.

214. Minion described. Inferior to puzzolana.—A particular red stone, found equal to forge scales, but could not find it in quantity.

215. Means of increasing the quantity of good water mortar.

216. The use of sand in mortar.

217. The proportion of increase of bulk of mortar by different quantities of sand.

218. Pursuit of the subject and introduction of pebbles.

219. Trial of clay in the composition of mortar, hurtful.

220. Stones naturally flat-bedded recommended for water building.

221. Flat backing recommended in preference to rough rubble.

222. Table containing 20 compositions of water mortar suited to different situations and circumstances.

Observations on the table—in seven different heads.

#### BOOK IV.

##### AN ACCOUNT OF THE PROCEEDINGS OF THE CONSTRUCTION OF THE STONE WORK, &c. UPON THE ROCK, FROM THE BEGINNING TO THE FINISHING OF THE BUILDING, WITH AFTER OCCURRENCES.

#### CHAP. I.

##### CONTAINING AN ACCOUNT OF THE FIRST YEAR'S BUILDING UPON THE ROCK.

§. 223. 3d June, 1757, sailed out of Plymouth Sound to begin the work of the season. A difficulty arose in getting up the moorings. The manner of obviating it described.—Some danger attending this operation, was performed by the author. The buss successfully moored.

224. The fender piles, the shears, and windlass, and the transport buoy fixed.

225. The first stone landed; got to place and fixed, Sunday the 12th June, 1757. Next day the first Course completed.

226. The 14th, the second Course begun. A fresh gale arose, obliging the workmen to quit the rock.—Things secured in the best manner possible. The gale increasing, impracticable to get out of the Gut; otherwise than by passing the Sugar Loaf. Yawls could not both recover the buss. The Sea-horse yawl made her way westward to the floating light.—An hard struggle to the light yawl to regain the buss.—Next morning the wind shifted; and the Weston, obliged to quit the transport buoy and get into port. Afternoon the Sea-horse yawl got back in safety from the floating light.

227. The work proceeded with. The 18th, hands again obliged suddenly to quit the rock; and the Weston to go into port.—Several disasters described. The most considerable, the loss of several pieces of stone.—The author returned to Plymouth, to expedite the forming fresh stones instead of those lost.—In carrying out the stones, a gale of wind arose, obliging the vessel to run into Fowey harbour.

228. The 30th June the IIId Course closed; and the IIId begun.—A new tool contrived for getting up lost stones. Further progress reported.

229. Weather unfavourable.—Afternoon of the 5th July the work renewed; and pursued the next day. In the night the Charming Sally of Bideford wrecked upon the rocks, though the weather was fine.

230. The 12th, the IIId Course completed, and the IVth begun. A sudden violent gust of wind, which as suddenly ceased.

231. Company driven home in bad weather for want of provision. An alarming accident; but without hurt to the people.—Seamen pressed from a vessel laden at Portland with

stone for the Edystone; but discharged by an order from the Admiralty.

§ 232. Various interruptions; yet July 31, Course IVth completed, and the Vth begun. 3th August the work visited and Vth Course completed. A cramp applied to remedy an accidental defect. An additional boat called the Assistant, Samuel Medling, master, brought out her first cargo of stone; a gale of wind arose, obliging her to seek an harbour. The Edystone boat also came out. Lime and puzzolana being much wanted; an expedient contrived to get a cask of each from on board her. Course VI begun.

233. A meridian traced on Course VIth. The sea for the first time never having washed over the work at high water; this opportunity was taken to repair the pointings. The method thereof; and observations.

234. The 9th of Aug. four vessels arrived from Portland with stone. The 11th, the VIth Course completing the basement was closed in. Recapitulation of this part of the work.

235. Method of setting and fixing the stones described.

236. Further descriptions.

237. Method of making the mortar. Simple machinery used for hoisting the stones.

238. Further detail of the manner of setting. Application of wooden wedges.

239. Oakum trenails used and described. The manner of grouting.

240. The 11th August, Course VIIth begun. The method of fixing it described; with its centre plug, &c.

241. An accident to the author.

242. Further detail of the method of proceeding with Course VII, being the first circular course.

243. Difficulties described in landing the stones.

244. The works upon the rock visited by Mr. Weston. Manner of fixing the cubic joggles described. Those cubes might possibly have been dispensed with; but in such a situation, nothing should be omitted.

245. The author's reasons for using the joggles, in preference of other methods of steadying the work.

246. This building intended to be a column of proportionably equal strength. Short reasonings upon it.

247. Mr. Weston returned the 18th to Plymouth, leaving the author to see Course VII wholly closed. An hard gale arose, while working with links upon the rock. Things put in the best posture. The weather growing worse, the author returned to Plymouth. On the 24th it came to be a violent storm. The 27th, the author looked out with his telescope, and missed the shears; next day confirmed; and went out to reconnoitre the works; leaving orders for new shears. The shears and triangles gone; and also two of the largest stones which had been left chained upon the work. Damages to the windlass and its frame. The buss tole well.

248. Richardson sent word the 1st Sept. that the two large stones could be weighed. The 5d, the new shears set up, and the work recommenced that had been interrupted by bad weather since the 18th.—The method of getting up the stones described.

249. The weather favourable. Course VII completed. Mr. Weston, accompanied by the author, went to see the 1st stone of the VIIth Course laid; which performed, Mr. Weston returned.—The season continuing favourable, the VIIIth Course completed in five days; and on the 20th, the IXth far advanced, when the works were again interrupted by bad weather.

250. During the late favourable time, there had been uncommonly low tides, which produced an hindrance in shipping the stones. An expedient made use of by Mr. Jessop. A malevolent intention to retard the progress of the work brought to light.

251. On the 26th the work recommenced. A great swell in the Gut from easterly winds. Great difficulty and hazard in landing the stones, necessary to complete the IXth Course.

252. Best method of going into and out of the Gut described.

253. State and progress of the works considered. Being the eve of October, resolved to put a period to the outwork of the season.—The shears and windlass taken down. An imminent danger escaped in getting the transport buoy on board.

254. October 1st, the Neptune buss prepared to cast off her moorings. The author, attended by Mr. Jessop and the masons, revisited the rock; and rectified every thing that appeared amiss. Returned to Plymouth with the companies. The buss came in the next day, and laid up for the winter.—An incident described.

#### CHAP. II.

##### COMPREHENDING THE ACCOUNT OF TRANSACTIONS FROM (THE AUTHOR'S) LEAVING PLYMOUTH IN OCTOBER 1777, TO THE CONCLUSION OF THE WORKING SEASON OF 1758.

§ 255. Tempestuous weather till March. The great buoy on the moorings carried away. A reward offered for recovery of the moorings. New chains bespoken.

256. The proceedings proposed to be laid before the Board of Trinity House. A day appointed.—The author's work and propositions received the approbation of that honourable corporation.—A set of mooring chains offered by that board, and the author desired to acquaint them with his future proceedings.

257. The sweeping for the moorings proving unsuccessful, the author took a journey to Plymouth to expedite that operation.

§ 258. Reports the progress of the works at Mill Bay. Express arrives to carry him back to attend the House of Commons. Consultation with Mr. Jessop and the seamen about the sweeping. Expedients proposed.

259. Author returned the 30th. One of the anchors hooked, and secured. The 2d May, went out to weigh the anchor; got it to the surface, but a fresh gale coming on, obliged them to lower it to the bottom.—Bad weather till the 11th. In this interim a further expedient proposed; attended with success; and the buss, after some difficulties, moored.

260. The author landed on the rock. Reports the condition of the work, after the winter. All well; except the fender piles, ad gone.

261. The 14th May, the Portland stone work all finished in the work-yard. The 16th, new fender piles fixed, as also the shears, windlass, and transport buoy. The boats loaded with stone, and the first went out to the transport buoy. All being ready to begin, an unforeseen disaster retarded the works for some time.

262. The author attended to lay the first stone of this year, but prevented by ground seas from the 16th to the 23d May; when without any distress of weather, the buss got loose; and a fresh gale obliged her to return to Plymouth Sound. A buoy being placed on the western anchor, concluded all safe.

263. Bad weather till the 3d June. The buoy of the anchor then gone; therefore came to an anchor with the buss. Enquiry made at the floating light. The buoy seen floating, and two fishing boats in sight.—The sweepings for the anchor recommenced, and continued, but without success; by bad weather obliged to return.

264. Strong suspicion of the Polara fishermen. Search made, which confirmed suspicions of the cork buoy being cut up for crab pots and seines.

265. Frequent attempts to recover the moorings; and notwithstanding a declaration from the seamen, that they would not return till they had succeeded, yet all endeavours proved abortive.

266. The chain lately made in London arrived; and the corporation's chain from Falmouth repaired. The 1st July, the buss sailed with the new ground tackle. Was moored, and the work recommenced. Consultation for the late disasters.

267. On the 5th July the Xth Course completed; but the XIth, being interrupted by bad weather, not till the 18th.

268. The 8th Aug. the fundamental solid completed, with the XIVth Course. The well-hole for the stairs to be now begun; the difference of construction described.

269. The entry and well-hole begun with the XVth Course; and the weather proving good, on the 30th the XVIIIth Course was completed; which finished the entry and doorway. An accident happened, which might have been fatal; but without material damage.

270. A succession of bad weather, so that the solid was not completed till the 24th Sept. In this interval an accident happened, by which the workmen were detained upon the rock, being the only one of the kind.—One leg of the shears was also unfixed by hard weather, but in this state of the building, they could not fall: nor was any damage done, which accounts for a former accident mentioned § 248.

271. A wish to complete the 1st room, and make the building useful to keep a light thereupon, induced the author to proceed beyond the present period with the building this year. The practicability as well as utility thereof set forth. Also the method of performing it. The proposal communicated to the Trinity House and the proprietors.

272. The 26th Sept. Course XXV, being the first of the superstructure, completed. Mode of construction very different from the former. Account of it, and particularly of the joggles.—Joint stones necessary. Described.—Cramps necessary.

273. Method of applying the cramps.

274. The 30th Sept. Course XXVIII, being the first chain course, was completed; as was the 2d chain course, XXIX, the next day.—The reason of the chain courses.—Preferable to cramps, and taken from a like construction in the dome of St. Paul's.—Method of leading in the chains.—Extreme precaution allowable in such a situation, where time is not materially lost.

275. Oct. 2d, the centre for the first floor set up. Described. All the stones for the floor got into, and upon the building; but, in making this effort, the boat Weston had a narrow escape from a gale arising. The author returned to Plymouth, went out again the 5th, and saw the two first stones of the floor set. The shears and windlass taken down, as being done with this season.—Broken weather till the 7th; materials arrived for covering the building, and stores for furnishing the same. The floor proceeded with, but foul weather appearing, every thing put in the best posture of defence.—The author returned to Plymouth, leaving orders with Mr. Jessop. A storm ensued.

276. Next morning, Oct. 9th, the author looked out with his telescope, but the air being very hazy, could discern the house and the sea breaking over it, but nothing of the buss. The afternoon somewhat less hazy, but no appearance of the buss; which created apprehensions.—The 10th, air more clear; distinct view of the building. The buss really gone. This a day of double regret, as it brought the author a negative upon his proposal, for exhibiting a light from the house during the winter, § 271.

277. The same evening at 10, Mr. Jessop returned to Plymouth from Dartmouth Harbour, where the buss lay. Described the particulars of this storm since the 8th.—The 11th, John Bowden sent to Dartmouth to take charge of the buss. Every thing prepared for the author to go out the next morning.



with a set of workmen, to do what they could in securing things against the winter. A gale of wind at East came on, which rendered it to no purpose to attempt to go out.—This continuing for several days, brought home the buss on Friday the 13th, and on Sunday came on a storm, and a continuance of bad weather. The author left the necessary orders, and departed for London the 25th Oct. 1758.

## CHAP. III.

CONTAINING AN ACCOUNT OF THE TRANSACTIONS OF THE FOURTH AND LAST YEAR'S WORK, TO THE FINISHING OF THE BUILDING IN THE YEAR 1759.

§. 278. The lantern, balcony rails, &c. made in London. Bad weather at Plymouth, which was terminated by a violent storm; so that the works on the rock could not be visited till March. Transport buoy gone, as well as the buoy on the moorings, and the south fender pile. All the work of the building firm as it was left; and the triangle standing, with the stone suspended; yet a large stone washed from the top.—Seamen swept for the moorings. A further expedient proposed, and rewards offered, but all ineffectual. A new chain ordered; and an old chain and anchors procured.

279. Iron pillars for the lantern, cast by Mr. Prickett. Copper sash frames, by Mr. Kinnam. Lantern framed, and balcony rails made by Mr. Broadbent.

280. The author repeatedly attended the Trinity Board, who expressed their approbation of his proceedings. Consulted upon the proposal of an optician, respecting the figure of the glass of the lantern.

281. The author arrived at Plymouth 22d June; found all the stone work prepared, and all in forwardness. A violent storm the 15th had damaged the Neptune buss. Repaired, and with the seamen then in search of the moorings. Five of the best hands demanding more wages, discharged.—A bridle cable laid plant, requested by the seamen; and prepared.—The old chain carefully examined and repaired, and every necessary put on board the buss the 2d of July. Also the new chain, which arrived this evening from London by land.

282. 3d July, went out with the buss. Calms, &c. next day completed the mooring. Position described.—Completed the transport buoy; the shears and windlass set up. The work examined by the author, and found all sound and firm. Proceeded in setting the floor. A large stone found wanting. Probably washed from the store room. Expedient to supply its place.—July 5th, the sea quiet. South fender pile fixed. The rock quitted the first time for want of work. The stone arrived in the afternoon. Next morning the first floor completed, and centre cleared.

283. New method of hoisting the stones adapted to present circumstances described. The shelter proposed by the completion of a room gave an opportunity to leave the tools and materials on resting.—Uncertain weather. Working at nights now discontinued.

284. Author went out to instruct Richardson's company in leading the chains of the second floor. Message from Lord Edgcombe respecting the Duke of York.—Staid to see one of the chains led in, and returned to Plymouth.

285. Next day took the model of the lighthouse to Prince Edward, Duke of York. Attended his Royal Highness to Milford Bay to see the works there; which met his approbation. Author rowed off in a six-oared barge, and landed at six the next morning. The second floor begun.

286. July 21st, second floor finished. A room or story built complete in 7 days. Proceeded to fit the iron work of the door books for leading. Block tin wanted for this use, forgot to be brought out. An expedient for remedy. The method of leading described.

287. A seaman missing and recovered. The third floor begun, and completed the 29th. Two stories built in 13 days.—Adverse weather. The copper ball completed at Plymouth.

288. Weather uncertain. The 6th Aug. the author visited the work, the XLVth or Cove Course in hand, and completed with its two chains the 8th. This day an uncommon rainbow.—The 9th, the elliptical centre for the balcony floor set. The Weston arrived with stone, and in part delivered; but taken with a sudden fresh of wind. All hands ordered to her assistance; had a narrow escape, and obliged to return to Plymouth. The balcony floor begun; wind fresh obliged all hands to quit. The author returned to Plymouth.

289. Aug. 16. Weston delivered. The moveable shears taken down, and the windlass fitted to hoist the smaller pieces through the manholes or hatchways.—The 17th the main column completed. Its dimensions.

290. Balcony rails set up and completed. Proceeded in fixing the ports for the windows; and for temporarily securing the man-hole at top. The manner thereof described. Stone for the lantern arrived and unloaded.—The 1st course of the lantern being set, the author returned the 18th, leaving directions with Mr. Richardson for that and the stairs in the well-hole.

291. The lantern coming by land from London, for expedition's sake, by the carrier's inattention was left at Exeter. Arrived the evening of the 20th.—21st, the groundsel of the lantern applied and fitted to the stone work. Progress reported to the Trinity House.

292. The iron ribs of the cupola put upon the platform to form the copper roof upon it. Method of the construction.—The 24th Sept. the last course of the stone work of the lantern completed.

293. The 27th, Richardson and his company returned from the Edystone, having completed the whole of the stone work the 26th.

§. 294. B is the state of the progress of the work. The masons and timbers employed, except some returned for other uses.

295. Bad weather ensued.—Principal coppersmith taken ill. Trinity House desire to know the day that a light could certainly be exhibited in the building. The author's answer.—Wanting the principal artificer, the author worked at the copper-work of the cupola. The second coppersmith taken ill, as the first had been. A workman requested of another master, but refused. Assisted by the brazier of the dockyard. The Duke man of war, of 80 guns, drove by bad weather into Mill Bay. Grounded on the soft mud, and got off without damage.

296. Directed by the corporation of Trinity House to fix the day of lighting; so as to enable them to give a week's notice by advertisement.

297. The 12th Sept. the author sailed with necessary materials and workmen for completion of the house. Returned to expedite the remaining work.—King's yard brazier set to work on the copper funnels.

298. The 15th, two cargoes of materials landed. Workmen began their respective operations.

299. Manner of leading the iron groundsel of the lantern upon the stone.

300. The 17th, the copper cupola arrived. The shears and tackle set up, and the cupola hoisted. The method of hoisting described.—The 18th, the ball arrived, and screwed on by the author. The cabin bedsteads completed. The author and Mr. Jessop removed their beds from the buss to the house. After that bad weather came on, and cut off all communication with the buss.

301. The 21st all the copper sash-frames were got fixed: An accident to two of them in coming from London. How remedied. Artificers brought out, but could not be landed; a third coppersmith taken ill. The distemper said to be epidemic.

302. The 23d, artificers landed. The glazing of the lantern begun: 24 iron cramps fixed in the cupola by the author, assisted by a mason; the manner described.—The lead covering completed. Two more of the artificers taken ill.

303. The 28th, joiners finished their work. The articles described; and the manner of fixing thereof.

304. Reasons for the present disposition of the rooms to their respective uses.

305. Two chests of candles arrived and other stores. Cross bars brought out, and two smiths to fix them; but being only half the number wanted, sent back to make more. The author proceeded to fix them. A painter deterred from coming out, on account of the number taken ill. A mason employed in that work. Those taken ill sent home.—An accident to the author, which if unattended would probably have proved fatal.

306. The 29th, the glazing completed. The fixing the cross bars proceeded with, and their intention described. The principal glazier taken ill.

307. The 1st Oct. the disposition of 8 pair of cross bars described. The copper funnel for the kitchen fire was completed and tried. Also the tackle for hoisting the chandeliers. Tried the lantern by lighting candles in the day-time.—Two lightkeepers brought out, but could not land. Letters conveyed into the house by a keg. Its contrivance and use described.

308. The conductor for lightning begun to be fixed. The manner of it. One of the proposed lightkeepers happened an accident, the other was intimidated, and refused to enter upon his employ.

309. The 4th, stores, water, and materials landed. Every thing essential to the maintenance of a light completed, and three of the workmen agreed with to keep the light. An express this day sent from the Edystone to the board of Trinity House; giving notice for lighting the 16th instant. Notice also given to the master of the floating light. The sick glazier and disabled lightkeeper sent back to Plymouth.—A great sea about the rocks, a sensible motion in the house. The rocks elastic.—A ground sea mounting only to the windows of the kitchen, did not sensibly move the building. The minor lightkeeper apologized, and came into the house.—The 7th, the house begun to be cleared. The electrical conductor completed.

310. The 8th, two boats arrived with stores; and also the remainder of the cross bars; too great a swell for the great boats to go into the Gut; their stores put on board the buss. Afterwards removed by the yawls to the house. All the stones then intended got in, except four casks of water. The painting finished. The cross bars all fixed. The clock set up. Orders given to those who were to keep the lights.

311. The 9th Oct. at one in the morning the yawl brought the remaining four casks of water, and began to remove the men, beds, tools, &c. All got on board the buss at four; and began to unmoor. Found the eastern chain parted from the western. One of the links of the bridle part of the chain much worn. At four in the afternoon all the moorings got on board, and with a fair wind came to an anchor in Plymouth Harbour. Great joy to those on board, being without loss of life or limb to any one.

## CHAP. IV.

COMPREHENDING AN ACCOUNT OF OCCURRENCES SUBSEQUENT TO THE BRINGING HOME THE SEPIANE BUSS AT THE END OF THE SEASON 1759, TO THE PRESENT TIME.

§. 312. Few occurrences in the last thirty years. The building having remained in good condition. Bad weather after being

ing in the buss, till Oct. 15th.—The author then prepared to go out, to be present at the lighting; but prevented by a reverse of weather.

§ 313. The 19th went out, landed, and found all well. The house lighted on the 16th as directed; and every thing answered well. Seas in the late had weather broke up high. Window ports shut to windward, and stuffed with oakum. Motion of the house sensible. —A further supply of coals, water, and small stores, completed the provision for six months. At the proprietors expense. Reasons for this provision.

§ 314. A fresh coat of paint laid upon the pillars of the lantern to change their colour. The reasons thereof. Gave the inside of the cupola another coat of paint. The ventilation of the lantern proved complete. The floating light vessel unmoored, and went into harbour. Lightkeepers exercised in their business. The author slept in one of the cabin beds. Noise of the sea upon the rocks remarkable in moderate weather. Outside painting finished. An iron hand rail fixed, and the rough steps in part cut in the rock, completed. Coat of amber varnish over the whole painting omitted, till spring. Instructions in writing from the proprietors to the lightkeepers framed and hung up. Exhorted to a diligent discharge of their duty.

§ 315. The 20th Oct. at noon, sailed for Plymouth. Wind contrary. Remarkable appearance of the light at different distances. Accounted for.

§ 316. Comparative appearance of the light from the Hoar at Plymouth.

§ 317. The appearance of the lighthouse from the Hoar, and the seas breaking upon it in clear weather after a storm. Combined with what the author observed of the gathering and breaking of the sea upon the rocks, when he was in the building, furnished the idea given in the frontispiece. Winstanley's account not exaggerated.

#### OCCURRENCES AFTER LEAVING PLYMOUTH.

§ 318. Stormy weather the remainder of the year 1759. The house visited the 3th January 1760. Boat could not land. Small stores conveyed into the house by the keg; and a letter conveyed to the boat from Henry Edwards. Bad weather described. Put in great fear by the motion of the house. Some small damages. —The 10th again visited, but could only land in the small boat. Seamen examined, but could not find the mortar any where started.

§ 319. The 8th Feb. stores landed. The house examined by Bowden; found nothing amiss, except one pane of glass broke, as reported by Edwards. All well; but the south tender pile gone.

§ 320. Soon after this, a violent storm reported by Admiral Boscawen to the Admiralty. No accounts from Plymouth. The author wrote to Mr. Jessop. The house reinspected; but no damage, except to a part of the electrical strap. Lightkeepers well, and no complaint.

§ 321. In June 1761, Mr. Weston wrote to the author, informing that Mr. Jessop was then dead; and Mr. Richardson appointed surveyor in his stead. As desired, the author in answer advised concerning the renewal of the painting, and the electrical strap. § 322. The strength of the building doubted by the advocates for wood, in case of a storm of the greatest degree of violence. —One of this kind happened in the year 1762. Mr. Richardson being unacquainted to the relation; the effects were described by Dr. Mudge. —His letter inserted.

§ 323. This letter being wrote immediately after the storm, and mentioning that the lantern had suffered nothing, the author desired his friend to write a circumstantial account, after the house had been visited. Extract of Dr. Mudge's 2d letter.—Nothing was disturbed, except a small matter of putty from the glass of the lantern. Further descriptions of the effects of the storm.—Great damages done in the Harbour and Sound.

§ 324. The author called into Cornwall in the year 1766. Visits the Edystone.—Extract of his report to the proprietors of its state and condition.

§ 325. The author called a second time into Cornwall in 1777. Inspected the lighthouse. Found things in good condition as before reported.

§ 326. The author having a call to Plymouth Dock in 1787, again inspects the lighthouse; trigonometrical operations for determining its distance from the land.

§ 327. The condition materially and substantially the same as before, and particularly described. In the interval since 1777, Mr. Richardson died.

§ 328. The iron work very little injured. Methods originally taken, with intention to prevent injury thereof from the salt water. —Described.

§ 329. The lustre of the gilding of the ball impaired, but not effaced.—Some derangement by late storms to the lead cover of the balcony. The author apprized the agent hereof, and how it should be rectified.

§ 330. Reasons why lightkeepers are readily procured to the Edystone, and stay long there. The lighthouse an healthy and comfortable habitation. Anecdote.

§. 331. The inscriptions upon the building.

General abstract of the progress of the work of the Edystone lighthouse.

#### APPENDIX;

CONTAINING AN ACCOUNT OF THE ESTABLISHMENT OF THE PRESENT LIGHTS UPON THE SPURN POINT, BY DIRECTION OF THE HONORABLE CORPORATION OF TRINITY HOUSE, DEPTFORD STROND, LONDON.

§. 332. A patent granted to Mr. Angell in 1678, for continuing lights on the Spurn Point, which he had erected at the request of masters of ships using the northern trade.—Before the year 1766, the land had grown out to so great a length, that the position of the lights, so far from being useful, were in many cases become hurtful. An act for removing them passed in 1766, and the direction of the building given to the corporation of Trinity House of London. Also to erect temporary lights.

§ 333. The author employed on this occasion by that body. Attended the committee at the Spurn Point in June 1766; who examined the situation, and fixed the places of the new light-houses and temporary lights.—The author's opinion requested concerning the practicability of building with brick. Answered. Committee of opinion the new buildings should be placed as near the then present Point as possible. The principle of the low light machine, called a swape, recommended for the temporary lights.

§ 334. The author received directions from the Trinity House, London, stating the situations and dimensions of the new light-houses and temporary lights.—The order.

§ 335. Early in 1767, the author produced a set of designs for the light-houses and temporary lights to the board of Trinity House. Approved, and passed the common seal. Delivered to Leonard Thompson, Esq. who proceeded to the execution of the temporary lights; which gave satisfaction.—Mr. Thompson finding difficulties in the erection of the light-houses, the erection devolved on the Trinity House; and the 7th April 1770, Mr. Taylor of York became the contractor.

§ 336. May 1771, the author appointed surveyor. Since the year 1766, the sea had considerably encroached upon the eastern coast of the Spurn Point. An alteration in the situation proposed to the board, and agreed to. The piling increased. The contractor interrupted by the agents of Mr. Angell. An amendment of the act found necessary, and the works stopped above a year. Latter end of 1772 the high light begun; its situation also altered. The distance of the lights stated.

§ 337. In the year 1774, the author remarked the rate at which the coast was wearing away. Danger to the low lighthouse thence apparent.

§ 338. In 1776, a great storm took away the entire site of the old lighthouse. Brought down a part of the circular court wall of the low lighthouse. The method of stopping further progress for the present.

§ 339. To defend this lighthouse for a permanency, appeared to the author impracticable. A repair of the breach recommended, and a temporary defence as long as easily tenable. The present high light machine to be applied as a low light. Approved by the board and executed.

§ 340. This accident did not materially retard the work.

§ 341. The houses desired to be lighted before the ensuing winter. Stone coal of Yorkshire of the nature of kennel recommended, and agreed to be tried.

§ 342. The 25th Sept. 1776, the fires were kindled with stone coal, and gave entire satisfaction.—The high light machine immediately removed into the line of direction. Its situation described: made moveable on rollers.

§ 343. In the first winter some defects at sometimes shewed themselves in the funnels as to venting the smoke. A remedy applied to the low light; afterwards applied to the high light.—April 1777, the author visited the Spurn Point lighthouse, and certified the whole works contracted for by Mr. Taylor were finished. The lights had given entire satisfaction; and the court wall of the low light standing in good condition.

§ 344. Inconvenience of the Spurn Point for want of fresh water. The author ordered a well to be sunk towards the middle of the peninsula. Reasons for this procedure. Water obtained, which though not perfectly fresh, was but barely brackish.

§ 345. The author visited the Spurn Point in 1786, took a survey of it. The well then destroyed, though it had been very useful. The isthmus descended, over which the sea breaks into the Humber.

§ 346. The low lighthouse being demolished by the sea, its use supplied by the temporary light machine. Manner of its demolition.

§ 347. An unexpected circumstance in the appearance of the lights, surprised the author, which he is at a loss to account for.

§ 348. The Spurn lights uncommonly brilliant.

§ 349. The principle of the air draught of this lighthouse explained.



## INTRODUCTION.

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THE building of Watch Towers, now called Lighthouses, for the direction of mariners, has doubtless, from the obvious utility thereof, had its rise in the earliest ages; and in several instances has been the object of royal magnificence. None however was so much celebrated amongst the ancients, as the Pharos of Alexandria, which has been accounted one of the seven wonders of the world. This famous tower was built by the PTOLEMIES kings of Egypt and successors of ALEXANDER; it is supposed to have been finished about 283 years before the Christian era, that is, 2070 years since, and had the name of PHAROS from the island; upon a rock at the eastern end of which it was built, so that its walls were washed by the sea. It was a square edifice of a white hard stone, and was built in a style astonishingly superb. According to the Nubian Geographer, a writer of the 12th century\*, its height was 300 cubits; that is, 547 feet English measure; and a fire upon the top of it was constantly kept burning in the night, to light such ships as sailed near these dangerous coasts, which are said to be full of sands, and shelves of rocks: and according to JOSEPHUS†, it could be seen at the distance of 300 stadia; that is 41½ English miles‡.

THE size of its base is not so well ascertained; and indeed, as a Lighthouse, it is not so material. A scholiast on LUCIAN takes upon him to assert, that it was a stadium in base! but this must have been a random stroke; as it would make the Pharos to have been greater in bulk than the great Pyramid, and therefore in that respect taking place of it as one of the Wonders. The same scholiast also asserts, that it could be seen at the distance of 100 miles; but this is quite impossible: for a tower 547 feet high, cannot be seen above 29 miles from the surface of the sea; the rest of the distance mentioned by JOSEPHUS, must be obtained by an elevation of the observer's eye above the sea; which at the height of 111 feet, would enable him to gain a sight of the fire upon the tower at the distance of 300 stadia: and an elevation of this kind we may very well suppose to be afforded from the tops of the masts of their largest ships, especially when lifted up upon the top of the waves of the sea: whereas to see the fire at the distance of 100 miles would not only require the tower itself to be 560 yards in height; but the observer's eye to be elevated as much: a situation which does not seem afforded in this flat country.

JOSEPHUS in another place, speaking of a magnificent building called the Phasaël at Jerusalem§, says it was 40 cubits in length and breadth, and about 90 cubits in height; and in its appearance resembled the Tower upon the Pharos, which gave a light to those who were sailing to Alexandria; but in its circuit it was much bigger.—According to this account the Pharos could not be so much as 73 feet in base, so that if the walls of it were 20 feet in thickness upon the

\* Geog. Nub. p. 94. Paris Latin Edit. 1619.

† Joseph. Bell. Judaic. l. iv. ch. 11.

‡ It perhaps may not be amiss to observe, that this reduction of the ancient measures to those of England, is on the supposition that the Egyptian cubit, and which I understand was likewise the cubit used all over Palestine, Asia Minor, &c. consisted of 21,888 inches nearly; as has been ascertained from the pillar still remaining on an island in the Nile, upon which the cubits supposed to be marked thereon 3000 years ago, are still used for the original purpose of measuring the height of its inundations. For though the Nilometer now standing is said to have been erected in the 8th or 9th century by OSMAN, yet it is supposed to be an exact copy, in the upper part at least, of the ancient one. And there is still the less doubt that this was the true measure of the cubit, as this remarkable circumstance has been noticed concerning it; that 400 of those cubits making a stadium, 500 such stadia make a degree of the meridian; agreeing with sufficient exactness to the modern measures, to shew that this measure of the cubit was not a mere arbitrary assumption; but intended to be the 200,000th part of a degree: The base of the great Pyramid, being a stadium of this measure.

§ Joseph. Bell. Jud. l. v. ch. 3.

ground, the clear hollow area it would contain could be only 33 feet square; a space in appearance (though there may be supposed rooms above each other) unequal to the containing a garrison, that CÆSAR is said to have thrown into it; that by commanding the narrow passage by it into one of the harbours, he secured by his ships the necessary supplies\*.

It however is not difficult to conceive how in this article JOSEPHUS might be mistaken, with regard to the relative bulk of the Pharos; for as he describes the Phasaël; viz. that after rising a considerable part of its height upon a large base, it was contracted on all four sides, by a broad platform with battlements round it; and that in the middle of this area there rose up a second building to a considerable height further; and as this description entirely agrees with that which the Nubian Geographer gives of the Pharos; it is probable the resemblance JOSEPHUS had in view, was chiefly this of the onward form: now if JOSEPHUS had been in use to see the Phasaël in the neighbourhood of Jerusalem, and the Pharos at a distance only; its height being in appearance lost by distance, he would suppose the circuit of its base to be less, in proportion to the less apparent bulk of the Pharos; for, if the Pharos was in reality double the Phasaël in bulk (as it probably might have been) yet as it was more than three times the height of the Phasaël, JOSEPHUS would be liable to have been deceived in the comparison of bulk or circuit; unless he had measured them both, or judged otherwise than from distant views.

THIS magnificent structure, called even by CÆSAR wonderful, was the work of SOSTRATUS of Cnidus: and we are informed by PLINY †, that PROLEMY very nobly permitted the name of the architect to be inscribed upon the building; who accordingly cut the following inscription upon the solid stone. SOSTRATUS THE CNIDIAN, THE SON OF DEXIPHANES, TO THE GODS PRESERVERS, FOR THE BENEFIT OF THOSE WHO USE THE SEA.

LUCIAN it seems has dropped a passage that has given a different turn to this business; which I should not have mentioned, had it not been to rescue the great architect from so invidious an aspersion. LUCIAN, though a satirist, and joker of those times, in the present case seems very grave; for in teaching his pupil the art of writing history, he bids him not to look out to please his cotemporaries, but to write for future times; and as an example bids him consider what the Cnidian artist did‡. When he had finished the work, he engraved his own name upon the stone, and smearing it over with mortar, he engraved upon that, the name of the king who then reigned; knowing that would happen, which did happen; that in a short period of years, the letters falling off with the mortar, there would come to view the inscription before set forth.

This account of the matter, though resting upon the single authority of LUCIAN, yet accords with that propensity of human nature, to lower all great characters, so much better than that of PLINY, that it seems currently adopted by the modern compilers of ancient history§; and indeed the story tells well enough in common conversation; yet as it appears to contain the evident marks of falsity, arising from the impracticability thereof, I have therefore no doubt but that PLINY's account is the truth.

Let us for a moment imagine the work to be done in modern London instead of ancient Alexandria: Can any one conceive it possible to get so many letters engraved of so large a size, and so deep, as to be suitable to so lofty a building; without its being known to several persons concerned in the execution; and in consequence soon getting to the ears of the king? Besides, it would not be easy to make use of any plaster or partial coating, the surface and colour of which could not be distinguished from that of the stone, in those critical examinations, that a public building of such *eclat* would unavoidably undergo upon its first completion. In reality the king could have little doubt of his own name being celebrated to posterity as the finisher of so great and useful a

\* Cæsar Com. de Bell. Civ. l. iii. sect. 112.

† Plin. l. xxxvi. chap. 12.

‡ Lucian de scribend. hist. § 52

§ See Dissertation sur le Phare d'Alexandrie, par MONTFAUCON. Acad. Royal des Inscriptions et Belles Lettres. Vol. vi. p. 577, dated 7th Jan. 1721.



work; this being generally ascribed to PTOLEMY PHILADELPHUS, the same who founded the Alexandrian Library.

IN respect to the expence of it, all ancient authors agree that it cost 800 talents; but as modern authors differ very greatly in the value of those talents; and we are furthermore at a loss to judge what proportion subsisted betwixt the value of work, and that of money in those times, compared with our own; we are as much unable to compare its cost, as we are its real bulk, with any of the structures of modern times\*.

AN edifice of so great a size, so well built, and of such durable materials, as this building is described to have consisted of, one might very well have expected to be existing at this day: but this is not the case; there is indeed still a Lighthouse, but of a much more humble form, rising out of the midst of an irregular castle or garrison, kept in this island, and which is now called Farion.—Upon what occasion this famous building was destroyed or met its destruction, history is, as far we know, totally silent: but the Nubian Geographer mentioned before, speaks of it, not only as a building subsisting in his time, but in perfect good condition: for, he says, there is nothing like it in the whole world, for the fineness of the edifice, or the strength of its structure; for, besides that it is built of the hardest Tiburtine stones, these stones are also joined together with melted lead, and so firmly connected that they cannot be loosened from one another; for the sea beats against the very stones wherewith it is built, upon the north side †.

ABULFEDA an Arabic writer who lived in the 14th century, amongst the stupendous monuments of Egypt ‡, describes the Pharos as being 180 cubits high; that is 120 cubits less than it had been described by former authors; and particularly the Nubian Geographer, who seems the most particular, and best founded: so that whether some decay happening in the upper works (where indeed it was most likely to happen) had occasioned its height to be reduced, as the least expensive mode of repair; or that ABULFEDA measured by some other cubit than the ancient one; or that he has spoke of the dimensions at random, or by hearsay, is now uncertain: but still, as the lower and most solid parts were remaining about 400 years ago, it is evident that some extraordinary fate must have happened to it since that time; which cannot be accounted for merely by the neglect of it, consequent upon the ruin of that empire. To have pulled it down would have been a work of so much labour, that even a wanton desire of destruction would have been foiled in the attempt: and it is scarce possible to see that the demolition thereof could answer any real purpose. Nor can we suppose that it has been undermined by the sea's gaining upon the rocks it was built upon; as those are said to be of granite. It seems therefore the most likely that it has been destroyed by the shake of an earthquake, at the same time producing a subsidence: and to this, the observations of modern travellers give some sort of countenance; as it is said that the foundations or ruins of art, are still seen amongst the rocks of the island Farion, under the surface of the water. At any rate we have authentic testimony of this stupendous tower's having subsisted for a period of 1600 years§.

FROM this Lighthouse, as the most celebrated, structures of this kind have generally obtain-

\* The computations of the value of those 800 talents in English money, by different authors, differ no less than from 330,000 to 80,000 pounds sterling.

† The height of 300 cubits mentioned by this author, he leaves in no doubt, as to their being the ancient cubit; because, he also says, the height of this building is 100 statures of man; so that taking the cubit, as before, at 21,888 inches, the stature of man will come out 5 feet 5½ inches; agreeable to the stature of the Egyptians, which is said to be rather low than tall.

‡ ABULFEDA's description of Egypt translated from the Arabic into Latin by Professor MICHAELIS.

§ ABULFEDA mentions, that there was formerly, viz. about the beginning of Mahomedanism, in this Lighthouse, a Speculum formed of Chinese steel, in which the shipping could be seen in the port of Constantinople; but of which it was deprived by the intriguing practices of the Christians.—That such a Speculum might be formed, and erected with such intent, is not to be disputed: but Constantinople being distant from Alexandria no less than 700 miles, as it was impossible for an observer at the former to see the Pharos, so it was as impossible for a person on the Pharos to see any thing at Constantinople; it being equally impossible that any thing could be seen by reflexion, which an observer at the Speculum could not see by a direct view; and therefore if such a Speculum ever existed, its removal may be accounted for, without having recourse to the intriguing arts of Christians, or others; namely by its not answering the end for which it was made.

ed the same name; as the Faro di Messina and others: but the most remarkable amongst the moderns is the Tour de Cordouan situated near the coast of France, upon a small island near the mouth of the river Garonne in the bottom of the bay of Biscay.

THIS LIGHTHOUSE was begun above 200 years ago, in the reign of HENRY II. of France; was 26 years in building; was finished in the reign of HENRY IV. in the year 1610; and was the work of LOUIS DE FOIX a celebrated French architect.

THE island upon which it is built is dry at low water, and wholly covered with the tide at high water. It is a bare rock, the upper surface of which, except its natural asperities, is nearly level, and at low water is about 500 fathoms in length, from north to south, and 250 fathoms in breadth from east to west. It is surrounded with detached rocks, which giving a resistance to the seas, they break upon them in blowing weather, with an horrible noise: and the access to this tower is rendered very difficult by the great surf that generally breaks upon it; so that nothing larger than boats of three tons burthen can approach it with safety; and that only by one passage of sixty fathoms wide, reaching within 100 fathoms of the tower, where there is a sand, upon which the boats ground at low water.

ON the level rocky surface above described, and nearly in the middle of the island, the building is founded; and the base fills a circle of no less than 135 feet in diameter, English measure.—Upon the whole extent of this base, the work is carried up entirely solid with masonry (except the opening of the stone stairs) to the height of eight feet, or thereabouts, which I suppose to be nearly on a level with the surface of the sea at high water. A cavity is then left in the middle of the area, of above 20 feet square, to form the cellar, and a fresh water cistern; this rises eight feet more, including the arches that cover it. The remainder of the area is built up quite solid with masonry (except the opening before mentioned) to the level of the top of the arches; the whole there making one regular floor or platform; but as the outside surface is built sloping or battering (as it is termed) from the perpendicular, the diameter of the greatest circle is there reduced to 125 feet.—The stone stair-case begun, and carried up in the solid, from about four feet high above the rock, to the platform already described, is on the east side, being that next the shore. The ascent from the rock to the beginning of the stone stairs, is on the outside, by a wooden ladder, and the entry is shut by strong wooden doors, on the outside.

Within the circumference of this platform, at the distance of 12½ feet, is drawn a circle of 100 feet diameter; and the space of 12½ feet between the inner and outward circles, limits the thickness of a circular wall; which is carried up somewhat battering on the outside, and perpendicular within, to the height of 12 feet, being 11 feet thick at the top; which circular figure, renders this wall, which in itself is so stout, still more able to resist the action of the western seas, in like manner as the parapet of a Mole.—There seems in the whole building no idea of defence against the attacks of an enemy; yet to defend the entry against small thieves and plunderers, a lodgment, in fortification called a Machicoulis, is built upon the wall over the stairs.

IN the middle of this clear area of 100 feet diameter, the base of the tower is begun upon a circle, the diameter of which is 50 feet; and the building is carried up from thence, by diminishing stories, to the height of 115 feet; at which level is the base of the lantern, which originally was of stone, and domed over; the doming being supported upon eight stone pillars or mullions, with openings between them for the passage of the light; and it was finished above, with small spire-like ornaments.

THERE being according to this description a space of 25 feet between the inside of the circular wall, and the outside of the tower; this space is in part occupied by several small rooms, which were built within the parapet, and served as lodgings for four light-keepers; and also for store-houses, for the reception of the different articles necessary for their own maintenance, as well as for the light itself: so that the light-keepers having nothing to do in the several other apartments of the tower (the cellar excepted) but to go up a circular stair-case, carried up (partly



in the thickness of the wall, and partly on the outside) from the level of the platform, to the commencement of the lantern; the different apartments of the tower are by that means preserved clean, and free from incumbrance.

THOSE different stories and apartments being highly finished, and ornamented within and without, a further description of a subject but little known in England, will I doubt not be agreeable to my reader.—There are four different stories that principally distinguish themselves on the outside, and are ornamented with columns of different orders. Those of the base story are Doric, the next seem to be a species of the Ionic, the third are Corinthian, and the uppermost, which ornament the lantern, are of the Composite order.

THE principal room on the ground floor is a great Hall of 22 feet square, by 20 feet high, to which are annexed two wardrobes, and other conveniencies; the whole arched over. Above this, on the first floor, is the king's apartment, comprehending a grand Saloon 21 feet square, and 20 feet high; a Vestibule, two wardrobes, and other conveniencies, which are arched over with flat elliptical arches. The next floor above, or second chamber floor, is taken up by the Chapel, where mass is performed, as often as the weather will permit the officiating priest to attend. This is a circular room covered with a dome, the internal diameter of which is 31 feet; its height from the floor to the top of the cornice of the Corinthian pilasters, wherewith the inside of the chapel is ornamented, is 22½ feet, and the dome being higher than hemispherical, makes the whole height near 40 feet. The inside of the dome is a rich Mosaic, and receives light from eight luthern windows regularly disposed. There is also a circular opening in the crown of the dome, of four feet diameter, not open to the sky as that of the Pantheon; but being surrounded with a circular balustrade, and covered with the inferior lantern, it will have much the same appearance as the dome of St. Paul's, when looking up from the floor on the inside.

The diameter of this third story, or inferior lantern, is 14 feet within. It is surrounded with a circular parapet, forming a Balcony round it; the internal diameter whereof is 21 feet, and it forms the cap of the solid stone cover of the dome of the chapel. This lantern is enriched on the outside with eight Corinthian Pilasters, applied to the eight supporting pillars, or mullions, between which are eight glazed windows, 2½ feet wide, and seven feet high. The inside, which in this story is less ornamented than it is without, is 20 feet up to the square; and being covered with an hemispherical cupola, its whole height is 27 feet; and it is closed with a solid stone arch, which serves as a basement to the lantern for the light.—The lantern just described seems destined to no particular use; serving only to give, by an agreeable figure, and a just gradation of diminution, the required Elevation of the principal light: it may however be conceived to be of occasional use; for being glazed, a lamp or lamps, candles, &c. may be placed in any of its windows, at pleasure, and give a full light in any direction, for any particular service for which it may be wanted.

The original lantern for the light was of a diameter somewhat exceeding five feet clear, within, and nine feet without; and, as already said, was externally ornamented with eight pillars of the Composite order. The unglazed openings between the supporting pillars, being but little bigger than the solid mullions, those openings therefore could scarcely exceed twelve inches wide in the clear. The height of this lantern was 17 feet to the top of the cupola, which was of stone; and there, a perforation was left in the middle of it about 18 inches in diameter, by which the smoke of the fire might ascend into another little turret of 2½ feet external diameter; and pass out of its openings, which somewhat resembled pigeon-holes. This little turret was capped over with a solid stone cupola, upon which a small stone spire or pinnacle was erected, that terminated the whole at the height of 31 feet above the floor of the lantern of the light. The total height of the building therefore was 146 feet English measure, above the base of the tower; and 162 feet above the surface of the rock.

BESIDES the ornaments already described, the king's apartment was decorated with the arms of France, and also with the busts of HENRY II. and HENRY IV. in niches: likewise with

a figure in stone representing Mars, with his proper attributes; and a female figure in stone, holding a palm in one hand, and a crown in the other. The bust of the architect *LOUIS DE FOIX* was placed in the chapel: to which the busts of *LOUIS XIV.* and of *LOUIS XV.* were added in the year 1735.

I have here described the ornamental parts as being of the Greek and Roman orders, to which indeed they the most nearly refer; but a number of ornamental parts and mouldings, derived from the Gothic architecture, are intermixed; such as turrets, pinnacles, &c. the composition of the whole is however in a style really grand and striking.

*M. BELIDOR*, from whose description and draughts\* I have extracted what relates to this tower, seems to blame the architect; and much to lament that so great a profusion of ornaments should have been bestowed upon so inhospitable a place†. But here it seems to me, that *M. BELIDOR* somewhat mistakes the matter. Had this building been erected at the cost of private adventurers; their endeavours no doubt ought to have merited the approbation of their fellow citizens, though they had contented themselves with merely doing what was necessary; provided they had not stopped short of doing that in the best way: but as this work appears to have been undertaken and carried on by a Series of Kings, who probably had the Pharos of Alexandria in view; the Tour de Cordouan must have been intended by them, not only as a work of public utility, but as a work of Magnificence: for, according to *Mr. POPE*, " 'tis only use that sanctifies expence."

TO the above account it is necessary to add, that the fire made in the lantern was of oak wood, deposited in a kind of large chafing-dish, elevated about six feet above the floor of the lantern; and that the bulk of the fire must necessarily exceed the bulk of the mullions; otherwise, when a mullion interposed to the eye of the spectator at a distance, he would perceive little, or rather, would not be able to perceive any light: this, in consequence produced a larger bulk of fire than otherwise might have been necessary; so that after the period of a century from the finishing of the building, it was found, that the fire had calcined the inside of the walls, and to prevent its falling‡, the French court ordered the lantern to be taken down in the year 1717, and the fire to be lighted below.—The change however had not long subsisted before the whole marine complained of their not being able to see the light at sea, at the distance of two leagues§, as they used to do: and in the year 1720 this occasioned *M. LE COMTE DE TOULOUSE*, Admiral of France, and *M. LE MARECHAL D'ASFELD*, Director of the Fortifications, to give the superintendence of this tower to *M. BITRI*, Engineer in Chief at Bourdeaux; who diligently applied himself to establish the light at its ancient height, and to remove the inconveniencies of the former; one of the most material, being the bulkiness of the stone mullions, which stopped a great part of the light that the fire gave.

HE therefore contrived, upon the platform which was the base of the former, to erect a lantern or cage of iron, consisting of four principal pillars, and supporting a cupola above, which was finished with a large ball, and a vane, 36 feet above the platform; and was completed in the year 1727, with all the success that was expected; after the public had shifted with having the fire below for the term of ten years||.

THERE is one thing described of this new lantern, that should not pass unnoticed; as it was

\* *Architecture Hydraulique*, Tom. iv. p. 151.

† " Il est seulement fâcheux, qu'un aussi bel édifice soit placé dans le lieu le plus ingrat du monde, qui ne méritoit point assurément la dépense qu'on y a faite; mais voilà comme en usent assez ordinairement, ceux qui ne sont qu'architectes; qui mettent sans distinction, des ornemens par-tout, sans trop se soucier de remplir l'objet principal." *BELIDOR*, Tom. iv. p. 152.

‡ From this circumstance it appears that this tower is built of a calcareous freestone, such as Portland, Bath Stone, &c.

§ Deux Lieues. *BELIDOR*, Tom. iv. p. 153.

|| It may here be remarked, that this entire change of principle in the re-construction of the lantern, took place many years after the establishment of a lighthouse upon the Edystone.



I apprehend, the first attempt of the kind. The lantern being entirely open, the smoke could escape on all sides: instead therefore of composing a funnel in the upper works as before, or forming an hollow cupola internally; the area of the great circle of the cieling of the cupola, was made the base of an inverted cone, whose Apex projected downwards about three feet: the entire sloping surface of this cone was then covered with tin plates, which becoming so many reflecting surfaces, served to increase the light of the fire, and made it to be perceived at a greater distance\*.

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THE CONSTRUCTION of a Lighthouse upon the Edystone Rock, has from its very origin, been considered as one of the artificial wonders of this kingdom: and so great was the curiosity of the public, at the completion of the present building, in the year 1759; and such were the numbers, by the intercession and recommendation of friends, that for some years after flocked daily to see the model; that, to avoid having the whole of my time consumed in satisfying their curiosity, I found myself under a necessity of deputing Mrs. SREATON, to shew and explain the model. I was honoured also with the command of his present MAJESTY, to shew and explain the same to himself, and our GRACIOUS QUEEN: when his MAJESTY shewed such a degree of attention to, and criticism thereon, as I have scarcely met with from any of his subjects. It was also exhibited to the late PRINCESS DOWAGER OF WALES, and the DUKE OF CUMBERLAND, at their especial requests; and the late DUKE OF YORK was pleased to honour the works themselves with his inspection, while they were carrying on at Plymouth.

The seeming avidity that the public shewed to be made acquainted with the detail of the construction of this building, concurred with other considerations, that I will presently mention, in determining me, to listen to the wishes of my friends, in publishing an account thereof; together with such matters, as in point of utility or curiosity related thereto, and might be acceptable: but nothing more effectually weighed in my mind, than the earnest request of the gentlemen who employed me in the work itself; and more especially as this was strengthened by the same request, from several gentlemen of the Trinity House; that I might publish an account of my proceedings; together with as much as I had learnt concerning the former buildings; to the end, that if any future unforeseen accident should unhappily cause the destruction of the present edifice, posterity might not be at a loss for the discovery of the errors and imperfections both of the present and former buildings; so as to avoid or pursue the principles already followed, as the improved genius and skill of the age should judge to be most expedient.

It is indeed as natural for me to wish, there may never be any occasion to resort to this treatise for that End; as it would be presumptuous to say there never could. He only who first created the atoms, can ascertain what is the full extent of those powers, that may possibly be combined, towards the destruction of the mass; but with respect to myself, it would surely be more creditable that the building should be permanent, than that it should be said to be well contrived, and the means of its restoration well described: and further, though the situation of this building is so peculiar, that there may not in the whole world be an occasion of erecting a structure perfectly similar; yet I have myself always found, that exact accounts of buildings which were in any degree remarkable, and actually executed, were much more instructive to my mind, than systematical writings†: and when a new method of operation, or a new Idea is once

\* We are told by the same author, that in fact it had this effect; but it would have been more satisfactory if we had been told, how long it continued to have that effect: as a reflecting surface placed directly above the fire, and exposed to the smoke, must be expected in a little time to get such a tarnish, as could not easily be rubbed off: and it may be a further query, whether the superiority of the light, might not altogether proceed from the lessening of the interposing solids; and from their having a fire grate containing 225 lb. French weight, of pit coals, which are said to be laid on at once, and to last the whole night; in lieu of a much smaller fire of oak wood; (which though it gave a great flame for the time, yet is said scarcely to have lasted three hours) rather than from the reflection of the tin plates.

† Previous to my entering upon the building of the Edystone Lighthouse, I perused PRICE's account of Salisbury Cathedral, and the Parentalia of SIR CHRISTOPHER WREN, with particular satisfaction: and though another stone for the base for the statue of Czar

sent forth, it is impossible to say, to how many good purposes it may by ingenious men be applied.

IN consequence of my determination to publish; some progress was made in the present work, between the time of completing the building, and the year 1763; and his MAJESTY having signified his pleasure to honour the design with his patronage, several drawings were prepared, and engraven, some of which were executed by the late celebrated Mr. EDWARD ROOKER: but by the time matters were brought into this train, I found myself so exceedingly pressed with business in my profession of a civil Engineer; and this being shortly after succeeded by an appointment, to be one of the receivers of the Derwentwater Estate for Greenwich Hospital\*; that, together with the hurry naturally attending the commencement of such an appointment, obliged me to suspend at that time, the further prosecution of the subject; and the consequent succession of engagements, not only in this, but at the same time in some of the principal undertakings in this kingdom, in my line of profession, which called me forth almost against my will†, put a total stop to any further proceeding upon the description of the Edystone Lighthouse, till the year 1783; when a severe attack upon my health rendered it adviseable, for the preservation of life, to desist from entering upon any fresh undertakings; by which means at the end of that year, I had so far got myself cleared of the pressure of former engagements, and was so far recovered in point of health, as seriously to begin to think once more of recommending my design.

I shall now proceed to give an account of the Edystone Rocks, and circumstances relative thereto, principally from my own observations on the spot, during the time of erecting the present Lighthouse; and of former Buildings thereon, so far as at this time I am able to collect the particulars.

PETER may not be wanted, amongst all the monarchs of Europe, yet the account given of that great operation by CARRUT, cannot but inspire every artist that reads it, with new ideas, accompanied by a wish that it had fallen to his own share to execute the same.

\* This arose from the patronage of the Earl of ELMORE, then first Lord of the Admiralty, to whom I had not the honour of being personally known; and the good offices of my much honoured friend the present Lord HOWE, then one of the Lords, and now first Lord of the Admiralty.

† In the spring of the year 1767 the Speaker's Warrant was served upon me to oblige me to attend the House of Commons, upon the proposition of the Forth and Clyde Canal, then proposed to be made from sea to sea in the south of Scotland.



## BOOK I. CHAPTER I.

CONTAINING

### A GENERAL ACCOUNT OF THE EDYSTONE ROCKS.

1. **T**HE subject I have before me, will I conceive be rendered more perspicuous, by beginning with a general description of the Edystone Rocks, as they exist in nature, independently of any building; as this will at once explain the source and reason of those difficulties, that must necessarily arise in the construction of an edifice upon them.

NAME.

2. THE Edystone Rocks are supposed to have got this appellation from the great variety of contrary Sets of the tide or current amongst and in the vicinity thereof; both upon the tide of Flood, and the tide of Ebb: and this uncertainty of the current, would be still further increased, from the following circumstances, to those who might not formerly be fully acquainted with the general Set of the Channel-Tide in these parts.

3. THE turn of the tide to the eastward from the west, and the contrary; that is to say, up channel and down, not happening at the time of high and low water, as is commonly the case in tide rivers; but the change of direction or time of Still Water, being when the water has flowed to half its height from low water, and when it has fallen from high water to half its ebb, it is said to change its direction at Half Tide; and the technical term for this disposition of the tides is, that they are said to run Tide and Half Tide: and it would be so in this district of the channel, whether there were any rocks here to interpose and disturb the regular Set of the tide, or not: which compounded with the particular Sets, occasioned by the interposition of this Congeries of irregular rocks, makes the currents in reality so irregular, that there is much need of a knowledge of the local situation, to shun the danger of coming near them; and therefore they may very properly be termed (as they are) the Edystone Rocks.

SITUATION.

4. THE Edystone Rocks are situated nearly S. S. W. from the middle of Plymouth Sound, according to the true meridian; which I always mean when not otherwise particularly expressed; that is, allowing two points of variation (as in the present times) of the north end of the magnetic needle to the westward; this will make their bearing by the compass, from the middle of the Sound, now, at or about S. W. and the distance, as nearly as I can collect it from observations, is  $12\frac{1}{2}$  miles; and from the same point in the Sound to the Jetty Head called the Barbican of the port of Plymouth is  $1\frac{1}{2}$  mile more, which makes the distance of the Edystone from the port of Plymouth to be nearly 14 miles. See Map of the Coasts, No. 2.

The promontory called Ram-Head is the nearest point of land to the Edystone, which bears from thence south, scarcely one point west, distant about 10 miles; and consequently by the compass is nearly S. W. b. S.—Those rocks are nearly in a line, but somewhat within that line, which joins the Start, and the Lizard points: and as they lie nearly in the direction of vessels coasting down and up the channel, they must, before a lighthouse was established thereon, have been very dangerous, and often fatal to ships under such circumstances; and many rich ships and other vessels, have in former times been actually lost upon those rocks, particularly such as were homeward bound from foreign Ports: it being even now, a common thing in foggy and thick hazy

weather, for homeward-bound ships, from long foreign voyages, to make the Edystone Lighthouse, as the first point of land of Great Britain; so that in the night, and nearly at high water, when the whole ranges of these rocks are covered, the most careful mariner might run his ship upon them, if nothing was placed there by way of warning.

5. I WILL by this time suppose my reader to have also laid before him the chart No. 1, of the Seas surrounding the Edystone lighthouse; from which he will see, that a line drawn from the Lizard point, to the nearest point of land upon the coast of France towards Ushant, will form the openings of the headlands of the British Channel, into the Bay of Biscay and the Atlantic Ocean; these headlands being distant from each other about 31 leagues. It is further observable, that the lighthouse lies, not so much as one half of that opening, in a north-east direction, within, or up Channel of the said line; and that the Bay of Biscay and Atlantic Ocean lie open to the Edystone, from the S. b. W. point to the W. b. S.; and in consequence, that it lies open to the swells of the Bay and Ocean, from all the south western points of the compass; which swells are generally allowed by mariners to be very great and heavy in those seas, and particularly in the Bay of Biscay. It is to be observed, that the soundings of the sea from the south westward towards the Edystone, are from 80 fathoms to 40, and every where till you come near the Edystone, the sea is full 30 fathoms in depth; so that all the heavy seas from the south-west, come uncontrolled upon the Edystone Rocks, and break thereon with the utmost fury.

6. A CIRCUMSTANCE that greatly tends to augment the force and height of the seas so breaking upon those rocks, is their particular form and position, as will in part be understood from the general Plan of the Edystone rocks No. 3, by which it will be seen, that they not only stretch across the channel in a north and south direction to the length of above 100 fathoms; but that they lie in a sloping manner toward the south-west quarter: and the sloping (or stiving of the rocks as it is technically called) does not cease at low water, but still goes on progressively, so that at 50 fathoms westward, there is 12 fathoms water; nor do they terminate altogether, at the distance of a mile; but at two miles distance there is doubtless clean Ground, being a white sand, as common to this part of the channel.—From this configuration it happens, that the seas coming uncontrolled from the deep water, and rather suddenly at last, though gradually meeting the slope of the rocky bottom, they are swelled to that degree in storms and hard gales of wind, as to break upon the rocks, with the most dreadful violence; as may in some degree (and in some degree only) be comprehended from the Tablet in the Title page. Nor is the effect of this slope less sensible, in proportion, in moderate weather; and it is frequently very troublesome even in calm weather; for the libration of the water, caused in the Bay of Biscay, in hard gales at S. W. continues in those deep waters for many days, though succeeded by a calm; inasmuch, that when the sea is to all appearance smooth, and even, and its surface unruffled by the slightest breeze, yet those librations still continuing, which are called the Ground Swell, and meeting the slope of these rocks, the sea breaks upon them in a frightful manner, so as not only to obstruct any work being done upon the rock, but even the landing upon it, when, figuratively speaking, you might go to sea in a Walnut-shell.

7. A STILL further circumstance, that even yet increases the difficulty of working upon the rock in moderate weather, will be apprehended from considering the particular plan and elevation No. 7 of what is now called the House Rock; every building having been made upon it, as the largest and highest; where, in the plan, upon the line A B, there is a sudden drop of the surface of the rocks, forming a step, of about  $4\frac{1}{2}$  or 5 feet high; this face or front exhibited in the upright view, also by the letters A B, somewhat overhangs the perpendicular towards the west; so that the seas which in moderate weather come swelling towards this step, meet so sudden a check thereby, that they frequently fly to the height of 30 and 40 feet, even when people are working upon the rock; and the broken water coming down upon the area of the lighthouse, the workmen must of necessity be thoroughly wetted, and often do their business in a very uncomfortable situation. I would not however be understood that this is the case, at all times in moderate weather; but only when the ground swells come home from the Bay; for when the wind is in any of the easterly or northerly points, that is, quite round from the south, by the E.



and N. to the west point, if moderate it produces no such effect; but yet, after a ground swell has been raised by a hard gale of wind at S. W. a wind blowing only moderately from the favourable points, will not quell it in less than 4 or 5 days time; and it is to be noted, that the south-westerly are the most prevalent winds of this part of the country, in the summer months, (when alone any thing can here be attempted with success) and that when the wind blows very fresh at any point, all work here must cease\*.

8. FROM what has already been observed, it will appear, that the turn of the current of the tide from the westward towards the east is at half flood; and that it remains in the same direction from that time forwards to high water, and afterwards till the half ebb: hence as the current of the tide, will in consequence during the whole of the time from half flood to half ebb, aid the ground swell from the west; and the water at this time is also high upon the rocks, it will very rarely admit of any business being done upon the rock, in the most moderate weather, during this interval; which of course at once cuts off half the time, in the period of every tide.

9. THE particular declivity of the rocks in a state of nature, will be readily judged of, by having recourse to Plate No. 6 that contains the elevation of the last Lighthouse; which is shewn by a south view at the low water of a spring tide. The high water of the same tide, supposed unagitated, would not rise to the top of the Peak of the rock, as it stood at the time of my taking the elevation, by three feet perpendicular; but the seas are scarcely ever so quiet here, as not to break entirely over it at high water. The sudden drop, step, or break of the house rock to the west, will be best explained by examining the Plate No. 9, containing the section of the present building; which section being upon the east and west points, distinctly shews this drop, or overhanging step, that creates so much trouble; there being, here, no other part of the rock before it, to hide it from the eye.

10. IT has been noticed, that the rocky ground at the bottom, extends considerably to the westward of the visible rocks; it does so also to the east, and to the north; in general, 14 to 20 fathoms deep at low water, at the distance of from a quarter, to half a mile; and, as I apprehend, still deeper to the southward; but of this last I have no minutes, having had no occasion to be particular there.—This rocky bottom is also another natural impediment to the working upon the rock; for every undertaker must alike experience the necessity of having a vessel of a competent size, to receive and lodge himself, his workmen and materials; and to have it moored in such a situation as to be sufficiently near, to effect a landing on the rock with small boats, whenever it shall appear practicable so to do; and carry to, and return from the same what materials he has occasion for. No man would however think of mooring his vessel to the south of the rocks; because, if it broke loose with a hard gale at south, he would be intercepted by the rocks in his passage home; or if moored to the west or east, if broke loose by hard gales from those quarters respectively, he would inevitably be driven upon the rocks, and the more perilous would be his situation, by being in the drift of the channel's tide; but on all the northern points, the land being within sight, no very heavy seas can ever come from this quarter; and therefore, if here he was to break loose from moorings, he will have every advantage in getting into port: but in this situation, though eligible for mooring, for the reasons abovementioned, the rocks are so very sharp, that a vessel lying at anchor in moderate weather, is in danger of having her cable or hawser chafed asunder, and of losing her anchor. Nothing therefore is to be done here properly without chains; and the weight thereof, that is necessary to prevent their being broke, or cut by the violent blows to which they will unavoidably be subject from those sharp rocks, is such as must render them unwieldy and troublesome in the management; especially to a vessel that for other reasons, cannot be encumbered with hands; and in reality, I found more difficulty and hindrance from this circumstance of a rocky bottom, than I could possibly have imagined.

\* This perhaps cannot be better illustrated than by observing; that to set the workmen forward, at different periods of the work, when there was to be a change in the mode of construction; I have been obliged to continue on board our store vessel at an anchor, frequently a week, sometimes 10, 12, 14, and once 18 days together, even in the months of July and August; when though the swell was quite gentle every where else; yet was it so furious upon the rocks, as to prevent our landing, though the common artificers were to be paid 6d. an hour for their work there.

## THE COMPONENT MATTER OR SUBSTANCE.

11. THE congeries of rocks called the Edystone, appear to me to be all of the same kind of stone, and of a kind so peculiar, that I have not seen any stone exactly like it in Cornwall or Devonshire, or indeed in any part of the kingdom; but the most similar to it that I have seen, was in Scotland, yet that varied in some degree from it. It is of the kind that in Cornwall they call a Killas or hard slate\*; but the substance thereof appears to be the same nearly, as the Moor-stone or Granite of that county; and it is in every respect quite as hard. It differs from the Moor-stone in this; instead of being composed of grains or small fragments, united by a strong cement, interspersed with a shining talky substance, as the Cornish Moor-stone in general appears to be; it is composed of the like matter formed into Laminæ commonly from one-twentieth to one-sixth part of an inch in thickness; the shining talky particles lying between the Laminæ†. It coheres as strongly together as Moor-stone, if split according to the direction of the grain; but if attempted to be split across the grain, it is abundantly harder, and therefore, when worked by tools, it can by no means be brought to an Arriss or sharp corner; because the texture is so much stronger one way than the other, that the force which is necessary to make an impression in the harder direction, is sufficient to crumble off the Laminæ from each other in that where they are less united. This stone is also in a considerable degree elastic, as will be shewn in the sequel, especially in endeavouring to divide it with the grain, which lies according to the stiving of the rocks; and is nearly one foot dip to the westward, in two feet horizontal, that is, in an angle of about 26 degrees with the horizon. The kind of work which can the most easily be done upon this rock is in boring or drilling holes into it, crossways of the grain, as will be observed in its proper place; every thing else goes on with much labour, and difficulty, except that of splitting it in the direction of the grain.

## GENERAL DIRECTIONS.

12. THE time of the tides here, that is of high and low water, is nearly the same as at Plymouth, viz.  $V\frac{1}{2}$  at full and change of the moon. The common Spring tides flow from 16 to 18 feet, and the equinoctial tides from 18 to 20 feet; neap tides flow from 11 to 12 feet, and sometimes to 14 feet.

The proper time of sailing from Plymouth for the Edystone is at high water at Plymouth: because the Ebb Tide from Plymouth Sound, will assist in getting out of the Sound, and then meeting the Channel's tide running eastward, the current will naturally set you so much east, that if your wind is slack, the return of the current to the west, at half ebb at the Edystone, will bring you back thither, in course, before low water, and give you the best chance of landing. The most favourable wind, both for going out, landing, lying there and returning, is at N. W.; for that wind not only answers for the passage both ways; but being a Land-wind, it must blow hard before it raises any considerable sea at the rock; and the landing-place being on the east side of the house rock, that reef, stretching north and south, becomes a Pier or Mole for breaking off the sea, from half ebb to low water, and from thence till half flood; which interval of time, when the weather permits, is the best for landing and staying there. The most unfavourable wind for every purpose is the S. W. as will easily be conceived from what has been already described.

\* PRICE's Mineral. Cornub. explanation of terms, p. 323.

† This is the account of it that I received from my ingenious friend the late Mr. WILLIAM COOKWORTHY of Plymouth, Chemist, who had been very curious in his researches upon the fossils, and particularly the Moor-stone of Cornwall; having found that to be a substance, which being acted upon by an intense fire, becomes the proper basis of China-ware; and a species of Moor-stone having been found by him not discoloured by the talky matter, a manufactory upon this principle has since been carried on at Bristol.

Having tried the specific gravity of Moor-stone and that of Edystone, I find the difference inconsiderable: Moor-stone being 2,625; Edystone 2,639 times that of water.



## CHAP. II.

CONCERNING THE CONSTRUCTION OF THE LIGHTHOUSE UPON THE  
EDYSTONE BUILT BY MR. WINSTANLEY.

13. **THE** many fatal accidents that were frequently happening to ships by running upon the Edystone rocks, and particularly to those that were homeward-bound, we must suppose to have made it a thing very desirable to have a Lighthouse built thereon, and that for many years before any competent undertaker appeared: for, from the circumstances which have been fully stated in the preceding account of the natural state of these rocks; it would appear to those then best acquainted with them, that the difficulties necessarily attending such an undertaking, were likely to prove insuperable: and perhaps in reality it may have been a peculiar advantage to every undertaker, and to the undertaking itself, that no one could, previous to the actual commencement of the work, be fully sensible of the difficulties which would inevitably attend it; and which he must surmount or fail of success.

14. **HOWEVER**, formidable as it was, we learn that in the year 1696, Mr. HENRY WINSTANLEY of Littlebury in the county of Essex, Gent. was not only hardy enough to undertake it, but was furnished with the necessary powers to put it in execution. This it is supposed was done in virtue of the general powers lodged in the Master, Wardens and Assistants of TRINITY HOUSE at Deptford Strond, to erect sea marks, &c. by a statute of QUEEN ELIZABETH, whereby they are empowered "to erect and set up beacons, marks and signs for the sea, needful for avoiding the dangers; and to renew, continue and maintain the same."—But whether Mr. WINSTANLEY was a proprietor or sharer of the undertaking under the TRINITY HOUSE, or only the directing engineer, employed in the execution, does not now appear.

15. **THIS** gentleman had distinguished himself in a certain branch of mechanics, the tendency of which is to raise wonder and surprize. He had at his house at Littlebury a set of contrivances such as the following:—Being taken into one particular room of his house, and there observing an old slipper carelessly lying on the middle of the floor; if, as was natural, you gave it a kick with your foot, up started a Ghost before you: if you sat down in a certain chair, a couple of arms would immediately clasp you in, so as to render it impossible to disentangle yourself till your attendant set you at liberty: and if you sat down in a certain arbour by the side of a canal, you was forthwith sent out afloat to the middle of the canal, from whence it was impossible for you to escape, till the manager returned you to your former place.—Whether those things were shewn to strangers at his house for money, or were done by way of amusement, to those that came to visit the place, is uncertain, as Mr. WINSTANLEY is said to have been a man of some property: but it is at least certain, that he established a place of public exhibition at Hyde Park Corner, called WINSTANLEY'S Waterworks, which were shewn at stated times, at one shilling each person: the particulars of those waterworks are not now known; but, according to the taste of the times, we must naturally suppose a great variety of *jets d'eau*, &c.\*

Those particulars relative to Mr. WINSTANLEY are indeed of little importance at present, either to the public or to the design of this publication, otherwise than as they may serve to give a sketch of the talents and turn of mind of this original undertaker; and to account for the whimsical kind of buildings that he erected upon the Edystone, for the purpose of a Lighthouse; as it

\* It appears that the exhibition of these waterworks continued some years after the death of Mr. WINSTANLEY, as they were existing in the month of September 1709, being mentioned in the Tatler of that date.

would seem, from the design thereof, that it was not sufficient for his enterprising genius, to erect a building upon a spot, where of all others it was the least likely to stand unhurt; but that he would also give it an elevation, that in appearance should be the most liable to subject it to damage from the violence of wind and seas.

16. THE following comprehends an account of two different buildings that he erected there, and is chiefly extracted from what was written upon the large copper plate print addressed to Prince GEORGE of Denmark, then Lord High Admiral of England, containing a perspective elevation of his finished Lighthouse; which, drawn orthographically and reduced to the same scale as the subsequent buildings are adjusted to, is shewn in Plate No. 5 of the present work. The account I refer to, is intitled by Mr. WINSTANLEY,

“ A NARRATIVE OF THE BUILDING.

17. “ THIS Lighthouse was begun to be built in the year 1696, and was more than four years in building: not for the greatness of the work, but for the difficultie and danger in getting backwards and forwards to the place; nothing being or could be left safe there for the first two years, but what was most thoroughly affixed to the rock, or the work at a very extraordinary charge: and though nothing could be attempted to be done but in the summer season, yet the weather then at times would prove so bad, that for ten or fourteen days together, the sea would be so raging about these rocks, caused by out-winds, and the running of the ground seas coming from the main ocean; that although the weather should seem, and be most calm in other places, yet here it would mount, and fly more than 200 feet, as has been so found, since there was lodgment upon the place: and therefore all our works were constantly buried at those times, and exposed to the mercy of the seas\*; and no power was able to come near, to make good or help any thing, as I have often experienced with my workmen in a boat in great danger; only having the satisfaction to see my work imperfectly at times, as the seas fell from it, and at a mile or two distance; and this at the prime of the year, and no wind or appearance of bad weather: yet trusting in God’s assistance for a blessing on this undertaking; being for a general good, and receiving most inexpressible deliverances, I proceeded as follows.

18. “ THE first summer was spent in making 12 holes in the rock, and fastening 12 great irons† to hold the work that was to be done afterwards; the rock being so hard, and the time so short to stay by reason of the tide or weather, and the distance from the shore, and the many journeys lost that there could be no landing at all; and many times glad to land at our return at places, that, if the weather permitted, would take up the next day to get to Plymouth again‡.

19. “ THE next summer was spent in making a solid body, or round pillar twelve feet high, and fourteen feet diameter; and then we had more time to work at the place; and a little better landing, having some small shelter from the work, and something to hold by; but we had great trouble to carry off and land so many materials, and be forced to secure all things as aforesaid every night § and time we left work, or return them again into the boats.

20. “ THE third year the aforesaid pillar or work was made good at the foundation from the rock to 16 feet diameter, and all the work was raised, which to the vane was eighty feet. Being all finished, with the lantern, and all the rooms that were in it, we ventured to lodge there soon after Midsummer, for the greater dispatch of this work. But the first night the weather came bad, and so continued, that it was eleven days before any boats could come near us again;

\* See the tablet in the title page.

† One of the irons about 3½ inches diameter octagon, was cut out in the operations of 1756.

‡ From this description it appears that they had not any store vessel to lie at moorings by way of constant retreat; but performed the work by single journeys.

§ Hence it appears they did not work in the night.



and not being acquainted with the height of the seas rising, we were almost all the time drowned with wet, and our provisions in as bad a condition, though we worked night and day, as much as possible to make shelter for ourselves. In this storm we lost some of our materials, although we did what we could to save them; but the boat then returning, we all left the house to be refreshed on shore; and as soon as the weather did permit, we returned again and finished all, and put up the light on the 14th of November 1698; which being so late in the year, it was three days before Christmas before we had relief to get on shore again, and were almost at the last extremity for want of provisions; but by good Providence, then two boats came with provisions, and the family that was to take care of the light, and so ended this year's work\*.

21. "THE fourth year, finding in the winter the effects the sea had upon the house, and burying the lantern at times, although more than sixty feet high; early in the spring, I encompassed the aforesaid building with a new work of four feet thickness from the foundation, making all solid near twenty feet high; and taking down the upper part of the first building, and enlarging every part in its proportion, I raised it 40 feet higher than it was at first, and made it as it now appears; and yet the sea, in time of storms, flies in appearance, one hundred feet above the vane; and at times doth cover half the side of the house and the lantern, as if it were under water†."

22. BESIDES the above narrative, this print of Mr. WINSTANLEY's contains the following information.

"This Lighthouse bears from Plymouth (or the entrance of the Sound) S. by W. and from the Ram Head, S. half a point eastwardly; and is distant from the anchoring in the foresaid Sound 4 leagues, and from Ram Head about 3 leagues and an half; which is the nearest shore from the said house: and the Isle of Maystone bears from the Lighthouse about N. E. by N. and is also four leagues distant; so that ships coming from the East or West, have much the same advantage of the light, that are bound for Plymouth. All the rocks near this house are on the eastward side, but stretching north, and most southwardly: all are covered at high water; but on the west side, any ship may sail close by the house, there being 12 or 13 fathoms water, and no hidden rock; but towards the E. by N. about a quarter of a mile distant from the house, lies an hidden rock that never appears, but at low spring tides, and therefore, not so well known, is the more dangerous.

\* Though Mr. WINSTANLEY has not himself left any particular representation of the building, described as the produce of these three years work; yet I am enabled to present the curious reader with the elevation thereof in plate No. 4. This is drawn orthographically to the same scale as the rest; from a perspective print said to be drawn at the rock by JAZZELL JOHNSTON, painter. I never saw but the single copy in my possession, and therefore at this time I must suppose it extremely scarce.

From the appearance of the basement, it would seem to be of stone; and though Mr. WINSTANLEY does not say in his description of the 2d year's work, which was that of making a solid body, or kind of round pillar, that it actually was of stone; yet from the manner of the expression one would infer that to be the case; and which will appear more probable if we may suppose Mr. WINSTANLEY and his workmen ignorant at that time, of the proper manner of composing a cement capable of becoming hard under the utmost violence of the sea; and in want thereof, he would doubtless after a winter's exposure, find the joints of his solid pillar to be much washed, and the work itself looking ragged: it was therefore a natural expedient to surround the former pillar as described in the 3d year's work, with a case of stone of a foot thick; and not only to make the joints with all imaginable care, but to surround every joint with a hoop or girdle of iron or copper plate, of some inches in breadth, to hold in and secure the mortar from the wash of the sea; which mode of security is inferred from the representation.

The height of the stone pillar here represented is 12 feet above the rock upon the upper side, and 17 feet on the lower side; it must therefore be supposed, in speaking of 12 feet high, Mr. WINSTANLEY means above the rock on the higher side; or, as the print from whence this is taken, appears to be made from an Eye Draught, it may be an inaccuracy in the draughtsman.

The elevation appears to be taken from the south at half tide, or when the sea is overflowing the landing-place; which of course occasions the rock to make a smaller appearance in this draught, than in any of the rest.

A is the eye-bolt and ring upon the landing-place. B the sloping surface of the rock. C the stone basement. D the store room. E the state room. F the open gallery. G the kitchen. And H the lantern for the lights.

† See the tablet in the title page; which yet is short of the height described by Mr. WINSTANLEY by 50 feet.

23. "THE sea ebbs and flows at this rock on spring tides 19 feet, and at high water all the rocks are covered, though a smooth sea; and it is high water at the same time as at Plymouth; but it runs tide and half tide, so that it runs East 3 hours after it is high water, and yet the sea falls lower; and it runs West 3 hours after it is low water, and yet the sea riseth. At low tides, especially spring tides, three great ranges of rocks appear very high, and lie almost parallel, stretching towards the S. E. and N. W. the house standing the most West of all. The fore-mentioned hidden rock is a full cable's length from all these rocks, and lies as aforesaid\*."

24. THE plate No. 5 I have already had occasion to remark is drawn orthographically from Mr. WINSTANLEY's perspective elevation, from whence the above narrative is taken, and wherein

A represents the rock at low water.—B the landing place, covered at half tide, and all the time the current runs East.—C the entry door.—D E the basement, which in the fourth year he describes to have been added to the original one of 16 feet, so as to make an addition of four feet in thickness on every side; from hence it seems, that on the west side at D, it has been a work of stone; the joints appearing to have been covered with hoop plates, as before described of the original base; whereas the east side E has the same appearance of having been wood; and to have been bound together with iron straps, as the whole of the superstructure evidently was.—F is the store-room with a projecting cabin to the south-east.—G the state-room.—H the kitchen.—I the open gallery or platform.—K the lodging-room.—L the attending, or look-out room.—M the lantern for the lights, surrounded by a gallery or balcony.

N. B. The base is supposed completely to contain the original stone base of 16 feet diameter, which with the addition of four feet all round, makes the base of this second structure to be 24 feet diameter; and it appears to be partly round, and in part a polygon: but the works above the base are evidently upon a dodecagonal plan, or polygon of 12 sides, till they rise to the base of the look-out room, where, with all above, the building assumes an octagonal figure.

25. IT is very unnecessary for me to enter into a further criticism upon either of those structures, as, with the information that I have collected, my reader will abundantly do that for himself; it is sufficient to say, that it was no small degree of heroic merit in Mr. WINSTANLEY to undertake a piece of work, that before had been deemed impracticable; and by the success which attended his endeavours to shew mankind, that the erection of a building upon the Edystone was not in itself a thing of that kind: and it will be a further confirmation of the exceeding violence of the seas upon those rocks; and of the augmented shock by the interposition of a building, when I mention, that on my first going to Plymouth in the year 1756, I was informed by an old gentleman who remembered both Mr. WINSTANLEY and his lighthouse, that after it was finished, it was commonly said, that in time of hard weather, such was the height of the seas, that it was very possible for a six-oared boat to be lifted up upon a wave, and driven through the open gallery of the lighthouse.

26. EXCEPT the above, I have met with no occurrences concerning this building till the month of November 1703, when the fabric needing some repairs, Mr. WINSTANLEY went down to Plymouth to superintend the performance thereof: and we must not wonder, if from the preceding accounts of the violence of the seas, and the structure of the Lighthouse, the common sense of the public led them to suppose, this building would not be of long duration; and the following is an anecdote which I received, to the same effect from so many persons, that I can have no doubt of the truth of it.

Mr. WINSTANLEY being amongst his friends previous to going off with his workmen, on ac-

\* For a more perfect account of the general shape and situation of the Edystone rocks, see the general plan thereof Plate No. 3; relative to which it is to be noted, that at the beginning of this century, the variation of the compass by Mr. FLAMSTEED was N. 7° ½ westerly; whereas it is now become nearly 2 points of the compass to the W. of N.; which, with the common inaccuracy of reputed bearings, sufficiently accounts for the difference of those given by Mr. WINSTANLEY, from these set down in this plan.



count of those reparations; the danger being intimated to him, and that one day or other the Lighthouse would certainly be overset; he replied, "He was so very well assured of the strength of his building, he should only wish to be there in the greatest storm that ever blew under the face of the heavens, that he might see what effect it would have upon the structure."

It happened that Mr. WINSTANLEY was but too amply gratified in this wish; for while he was there with his workmen and light keepers, that dreadful storm began, which raged the most violently upon the 26th November 1703 in the night; and of all the accounts of the kind, which history furnishes us with, we have none that has exceeded this in Great Britain, or was more injurious or extensive in its devastation.

The next morning, November 27th, when the violence of the storm was so much abated, that it could be seen whether the Lighthouse had suffered by it, nothing appeared standing, but, upon a nearer inspection, some of the large irons, whereby the work was fixed upon the rock; nor were any of the people, or any of the materials of the building, ever found afterwards; save only part of an iron chain, which had got so fast jammed into a chink of the rock, that it could never afterwards be disengaged, till it was cut out in the year 1756.

27. THE above accounts are what I have received from old people at Plymouth; the following anecdotes are extracted from a book, published soon after the melancholy accident to Mr. WINSTANLEY and those with him, entitled *The STORM*, printed London 1704.

"The loss of the Lighthouse called the Edystone at Plymouth, is another article, of which we never heard any particulars, other than this; that at night it was standing, and in the morning all the upper part of the gallery was blown down, and all the people in it perished; and by a particular misfortune, Mr. WINSTANLEY the contriver of it; a person whose loss is very much regretted by such as knew him, as a very useful man to his country. The loss of that Lighthouse is also a considerable damage; as 'tis very doubtful whether it will ever be attempted again; and as it was a great securitie to the sailors; many a good ship having been lost there in former times.

"It was very remarkable, that, as we are informed, at the same time the Lighthouse above-said was blown down, the model of it in Mr. WINSTANLEY's house at Littlebury in Essex, above 200 miles from the Lighthouse, fell down and was broke to pieces\*." Page 223.

"At Plymouth they felt a full proportion of the storm in its utmost fury; the Edystone has been mentioned already; but it was a double loss; in that the Lighthouse had not been long down, when the Winchelsea, an homeward-bound Virginia man, was split upon the rock where that building stood, and most of her men drowned." P. 212.

\* This however may not appear extraordinary, if we consider that the same general wind that blew down the Lighthouse near Plymouth, might blow down the model at Littlebury.

## CHAP. III.

ACCOUNT OF THE SECOND LIGHTHOUSE BUILT UPON THE EDYSTONE BY  
MR. RUDYERD.

28. **T**HE great utility that the Lighthouse of Mr. WINSTANLEY had proved itself to be of, during its continuance, would of course prompt mankind to wish for another in its place; and the loss of the Winchelsea Virginia man just mentioned, with others that may naturally be supposed to have shared the same fate, would doubtless prove powerful incentives to awaken the attention of those most nearly concerned, to attempt a work, that with whatever difficulties it might in reality be attended, yet Mr. WINSTANLEY's building had demonstrated to be a thing, not in its own nature impossible or impracticable.

It was not however begun afresh quite so soon as it might naturally have been expected; for Mr. WINSTANLEY's Lighthouse having been destroyed the 26th November 1703, it was not till the spring of the year 1706, that an act of parliament of the 4th of QUEEN ANN was passed for the better enabling the Master, Wardens and Assistants of TRINITY HOUSE at Deptford Strond, to rebuild the same; so that in the steps necessary for this, we must suppose some obstruction; but the work itself was begun in the July following\*.

29. **B**Y this act of parliament, the duties payable by shipping, passing the Lighthouse, were vested in the corporation of TRINITY HOUSE at Deptford Strond, and it included powers to them to grant a lease thereof to an undertaker or undertakers, such as they should approve. In consequence of these powers they agreed with a Captain LOVEL or LOVET for a term of 99 years, commencing from the day that a light should be exhibited, and continuing so long as that exhibition should last during the said term.

30. **U**PON this foundation Captain LOVET engaged Mr. JOHN RUDYERD to be his en-

\* Extract from the preamble to this act 4th of Ann, chap. 20th.

"And whereas there now is, and time out of mind has been, a very dangerous rock called the Edystone lying off of Plymouth in the county of Devon, upon which divers ships and vessels have been cast away and destroyed: and whereas upon application some time since made to the said Masters, Wardens and Assistants by great numbers of masters and owners of shipping to have a Lighthouse erected upon the said rock, offering and agreeing in consideration of the great charge, difficulty, and hazard of such an undertaking, to pay the said Master, &c. one penny per ton onwards, and the like inwards, for all ships and vessels which should pass such Lighthouse (coasters excepted, which should pay twelpence only for each voyage) they the said Master, &c. having a due regard to the safety and preservation of the shipping and navigation of this kingdom, did in the year 1696 cause a Lighthouse to be begun to be erected on the said rock: and in three years time a light was placed therein; and the said Lighthouse in the term of five years was, with much hazard and difficulty, and at a very great expence, fully built and completed to the great satisfaction of the flag officers and commanders of the fleet and ships of war, and of all others concerned in trade and navigation: the same being not only useful for avoiding the dangerous rock upon which it was built, but also a guide and direction to ships passing through the channel from and to all parts of the world. And whereas the said Lighthouse was preserved and kept up for several years notwithstanding the great force and violence of the wind and sea (to which it was exposed) until the late dreadful storm in November 1703, when the same was blown down and destroyed: and whereas it was found by experience that the said Lighthouse (during the standing thereof) was of public use and benefit to this kingdom, a means to preserve her Majesty's ships of war, and the shipping, lives, and estates of her subjects. —And forasmuch as the speedy rebuilding the said Lighthouse is absolutely necessary for avoiding the dangers attending the trade and navigation of this kingdom; and in regard the same work is of great charge, hazard and expence, and all due and proper encouragement ought to be given thereunto; to the end therefore that the said Master, &c. may be encouraged to new-erect and build, or cause to be new-erected and built the said Lighthouse with all convenient speed, and constantly keep and maintain the same for the benefit of the navigation and trade of this kingdom, be it enacted, &c." It then proceeds to enact the payment of the duties above mentioned, and double on foreign vessels "from and after the kindling or placing a light useful for shipping in the said Lighthouse."



gineer or architect and surveyor: and the event has shewn that he made a very proper choice; though it does not appear that Mr. RUDYERD was bred to any mechanical business, or scientific profession, being at that time a Silk Mercer who kept a shop upon Ludgate Hill, London; nor do we find that in any other instance he had distinguished himself by any mechanical performance before or after: yet this is no proof but that he might have made these kind of subjects his private amusements; and it is indeed true, that a natural genius with very slender experience, will go much further in Design, than experience alone is capable of; but when genius and a competent experience are united in the same person, it is to be looked upon as a happy combination; and their productions likely to be the most complete and perfect. However, Mr. RUDYERD's want of personal experience, was in a degree assisted by Mr. SMITH and Mr. NORCUTT, both shipwrights from the king's yard at Woolwich; who worked with him the whole time he was building the lighthouse.

It is not very material now in what way this gentleman became qualified for the execution of this work; it is sufficient that he directed the performance thereof in a masterly manner, and so as perfectly to answer the end for which it was intended\*. He saw the errors in the former building and avoided them; instead of a polygon he chose a circle for the outline of his building, and carried up the elevation in that form. His principal aim appears to have been use and simplicity; and indeed, in a building so situated, the former could hardly be acquired in its full extent, without the latter. He seems to have adopted ideas the very reverse of his predecessor; for all the unwieldy ornaments at top, the open gallery, the projecting cranes, and other contrivances, more for ornament and pleasure, than use, Mr. RUDYERD laid totally aside; he saw, that how beautiful soever ornaments might be in themselves, yet when they are improperly applied and out of place; by affecting to shew a taste, they betray ignorance of its first principle, Judgment: for whatever deviates from propriety is erroneous, and at best insipid.

31. IN like manner as Mr. WINSTANLEY; Mr. RUDYERD also, after the completion of his work, published a print entitled *a Prospect and Section of the LIGHTHOUSE on the EDY-STONE ROCK off of PLYMOUTH*; and he dedicated it to Thomas Earl of PEMBROKE, then Lord High Admiral of Great Britain and Ireland; with this motto, *Furit natura coerces ars*. The drawing by B. LENS, the engraving by I. STURT, both eminent artists of their time. This print I suppose to be very scarce, not having seen any other but the single copy I have in my own possession.

32. THE Plate No. 6 is an orthographic elevation and section of Mr. RUDYERD's Light-

\* Since writing the above, on perusal of the MSS. by my valuable and learned friend the Rev. Mr. MICHELL, he has communicated to me an anecdote concerning Mr. RUDYERD, when I least expected it: and as it is in itself curious, and comes so well authenticated, I will give it a place here; and perhaps it will come in better by way of note, than by being interwoven in the context:

The following particulars Mr. MICHELL had often heard his father repeat in his life-time, of this Mr. RUDYERD. They were both born in Cornwall; and his father being 18 years old when Mr. RUDYERD's Lighthouse was begun, was at a time of life when he was likely to pick up the current stories of the times; as well as sufficiently in the way to hear them, from his situation in the neighbourhood.—According to the late Mr. MICHELL's account, Mr. RUDYERD's father and mother were of the lowest rank of day-labourers, with a large family of children; and in as low repute in all other respects, as in point of rank; being looked upon as a worthless set of ragged beggars, whom almost nobody would employ, on account of the badness of their characters. Our Mr. RUDYERD, however, was from a child of a very different disposition from the rest; born with a good head, and an honest and a good heart, in short the very reverse of the rest of the family, so that he was considered by them as a sullen boy; as he would not associate with them in going out upon their pilfering schemes; and probably on that account, as hath been supposed, he ran away from them; and by good luck, and from something promising in his aspect, got into the service of a gentleman, supposed at Plymouth; and in this station he appeared to so much advantage to his master, and became so great a favourite with him, that he gave him the opportunity of reading, writing, accounts and mathematics; in all which he made a very ready and great progress; and afterwards his master assisted him very greatly in life, by procuring him some employment that raised him above the rank of a servant, and laid the foundation of his future success in the world.—The above account strongly evinces that though education and example may do much; yet that there is something in natural disposition, that is not totally to be eradicated by education. Had Mr. RUDYERD's parents been of the most amiable character, if one of their children had turned out the reverse, who would have wondered? We should readily have explained it, that it arose from ill impressions from without: but the wonder in this case is, that in spite of all the force of evil example, here is a mind capable of emancipating itself, by the most violent of all remedies, that young people generally take, that of separation from parents and household by flight.

house. The manner of it, is herein copied, on account of the compendium thereby suggested; which shews part of the outside and part of the inside, so as to be at once, both an elevation and a section; this seems worthy of imitation, as it avoids a greater multiplicity of designs than the subject necessarily requires: but the proportions of the several parts of the structure, are designed and drawn from fresh materials.

33. WHETHER it was owing to a kind of indolence, that some ingenious men are subject to, or to want of health, that we hear nothing more of Mr. RUDYERD after the publication of this print, does not now appear: I am rather inclined to suppose the latter; for had he continued in health and vigour, even if he had some slight turn of the former kind, yet the eminent abilities he shewed in this building, after finishing it with *eclat*, must have called him forth to the public service on some other subject. I therefore must conclude, that even when the design for this print was prepared for the engraver, Mr. RUDYERD's application must have been slackened by want of health; and that the drawing must have been compiled from some sketch or sketches of the building made antecedent to its execution: because in many particulars, it deviates from the proportions the building actually had; as fully appeared when there was occasion to examine it, by after surveyors: and that, in some particulars, which could not afterwards be changed, nor in reality were they. Yet as what is written upon the face of Mr. RUDYERD's print, is the only piece of writing of his that has been preserved, it will be proper to insert a transcript of it, pointing out by notes the principal inaccuracies thereof.

34. "THIS Edystone Rock lyeth 3 leagues S. E. and N. W. of Ram Head\*, and four leagues from Plymouth. The building was begun in July 1706; a light put up thereon and made useful the 28th July 1708, and completely finished in 1709. The rock stives from E. to W. 10 feet 11 inches in 24 feet, which is the diameter of the foundation†: 25 feet 6 inches is the largest circle that can be drawn upon the rock‡. The face of the rock is divided into seven equal ascents. There are 36 holes cut into the rock, from 20 to 30 inches deep; 6 inches square at top, narrowing to 5 inches at 6 inches deep, from thence spreading and flattening to 9 by 3 at the bottom. They are all cut smooth within, and with great dispatch (though the stone was harder than any marble or stone thereabouts) with engines for that purpose. Every cramp or bolt was forged exactly to the bigness of the hole it was designed for; they weighing from 2 cw<sup>4</sup> to 5 cw<sup>4</sup> each, according to their different lengths and substances§. These bolts served to tie the solid to the rock."

He mentions further in the literal references, that the outside timbers (since called the up-rights) were seventy-two in number; and so indeed they might have been intended, but the real number was seventy-one.

35. AS nothing would stand upon the sloping surface of the rock without artificial means to stay it; Mr. RUDYERD judiciously concluded, that if the rock was reduced to level bearings, the heavy bodies to be placed upon it, would then have no tendency to slide; and this would be the case, even though but imperfectly executed; for the sliding tendency being taken away from

\* It is supposed that by some error in the transcriber or engraver, these bearings should have been S. b. E. and N. b. W.; for then they will agree tolerably with Mr. WINSTANLEY's account, and with the variation of the compass at that time. The distances are doubtless according to vulgar reckoning.

† The diameter of this Lighthouse upon its base could not exceed 23 feet 4 inches, as I have fixed it; which I conclude from the extent of the work upon the surface of the rock, by which it was reduced into steps or level bearings.

‡ The diameter of the base of the present Lighthouse is 26 feet, nor does its circumference any where come nearer the border than one foot, so that a circle of 28 feet, which is 2 feet and 6 inches larger than Mr. RUDYERD describes, may in reality be drawn upon the rock: but the base was somewhat enlarged by cutting off the top of the rock in 1756.

§ Several of the bolts, or, as since called, branches, here described, were cut out of the rock in the year 1756; and found to be very different in dimensions and weight from what is here described; which seems rather what was intended before the work was begun, than what really was done, as already hinted. See the detached figure of one of them in Plate No. 7. The ascents were in reality very unequal.

these parts that were reduced to a level, the whole would be much more securely retained by the iron bolts or branches, than if for the retention of the whole, they had depended entirely upon the iron-work; as manifestly appears to have been the case with the building of Mr. WINSTANLEY.—According to Mr. RUDYERD's print, the inclined surface of the rock was intended to have been reduced to a set of regular steps, which would have been attended with the same good effect, as if the whole could have been reduced to one level; but in reality, from the hardness of the rock, the shortness and uncertainty of the intervals in which this part of the work must have been performed; and the great tendency of the Laminæ whereof the rock is composed, to rise in spawls, according to the inclined surface when worked upon by tools, urged with sufficient force to make an impression; this part of the work, that is, the stepping of the rock, has been but imperfectly performed, though in a degree that sufficed.

36. THE holes made to receive the iron branches, appear to have been drilled into the rock by Jumpers\*, making holes of about  $2\frac{1}{2}$  inches diameter; the extremities of the two holes forming the breadth for the branch, at the surface of the rock, were about  $7\frac{1}{2}$  inches; and these holes were directed so that at their bottoms they should be separated somewhat better than an inch more, that is, so as to be full  $8\frac{1}{2}$  inches. In the intermediate space, a third hole was bored between the two former; and then if the three holes were broke into one, by square-faced Pummels, this would make the holes sufficiently smooth and regular†. By this means he obtained holes of a dovetail shape, being  $2\frac{1}{2}$  inches wide,  $7\frac{1}{2}$  broad at top,  $8\frac{1}{2}$  at bottom, and 15 and 16 inches deep; and, as these could not be made all alike, every branch was forged to fit its respective hole. The main pieces of each branch were about  $4\frac{1}{2}$  inches broad at the surface of the rock, and  $6\frac{1}{2}$  at the bottom; and this being first put down into the hole, the space left for a key would be 3 inches at top, and two inches at bottom, which would admit it to be driven in so as to render the whole firm, and the main branch fixed like a dovetail or Lewis.—I shall now proceed to describe the manner of filling the interstices with lead, so as to make all solid, and exclude the water.

37. THE holes being each finished, and fitted with their respective branches, and cleared of water, a considerable quantity of melted tallow was poured into each hole: the branch and key being then heated to about a blue heat, and being put down into the tallow, and the key firmly driven; by these means, all the space unfilled by the iron, would become full of tallow, and the overplus made to run over: when this was done, all remaining hot, a quantity of coarse pewter, being made red hot in a ladle, and run into the chinks, as being the heaviest body, would drive out the superfluous melted tallow: And so effectually had this operation succeeded, that in those branches which were cut out in 1756, and had remained fast, the whole cavity had continued so thoroughly full, that not only the pewter, but even in general, the tallow remained apparently fresh: and when the pewter was melted from the irons, the scale appeared upon the iron, as it had come from the smith's forge, without the least rust upon it.—I have been the more minute in this description, because it shewed the perfection of this method of fixing iron-work into stone, even in the case, where the salts of sea water are ever in readiness to penetrate, could they have found the least admission.

38. ALL the iron branches which are shewn, as I found them, in Plate No. 7, having been fixed in the manner abovementioned; they next proceeded to lay a course of squared oak balks, lengthwise upon the lowest step, and of a size to reach up to the level of the step above.—Then a set of short balks were laid crossways of the former, and upon the next step compoundedly, so as to make good up to the surface of the third step.—The third stratum was therefore again laid lengthwise, and the fourth crossways, &c. till a basement of solid wood was raised, two complete courses higher than the highest part of the rock; the whole being fitted together, and to

\* The instruments so called are well-known tools for boring holes in the harder kind of stone.

† In this way I tried the making dovetail holes, and found the method very practicable: and in this way afterwards, in the course of the work we made various temporary affixtures to the rock; and made the Lewis holes in the Moor-stones.



the rock as close as possible, and the balks, in all their intersections with each other, trenailed together. They were also fitted to the iron branches where they happened to fall in; for the branches do not seem to have been placed with any complete regularity or order, but rather where the strength and firmness of the rock pointed out the properest places for fixing them: they were however to appearance disposed, so as to form a double circle, one about a foot within the circumference of the basement, and the other about three feet within the former; besides which, there were two large branches fixed near the center, for taking hold of the two sides of a large upright piece of timber, which was called the Mast; by which two branches, it was strongly fixed down; and being set perpendicular, it served as a center for guiding all the rest of the succeeding work.

The branches were perforated, in their respective upper parts, some with three, and some with four holes; so that, in every pair (collectively called a branch) there would be at a medium seven holes; and as there were at least 36 original branches, there would be 252 holes, which were about  $\frac{1}{8}$  of an inch in diameter; and, consequently, were capable of receiving as many large-headed spikes or Jag-bolts, which being driven through the branches into the solid timber, would undoubtedly hold the whole mass firmly down; and the great multiplicity of trenails in the intersections, would confine all the strata closely and compactly together.

39. I CANNOT omit here to remark, that though the instrument we now call the Lewis, is of an old date; yet, so far as appears, this particular application of that idea, which Mr. RUDYERD employed in fixing his iron branches firmly to the rock, was made use of for the first time in this work: for though Mr. WINSTANLEY mentions his having made 12 holes, and fixed 12 great irons in the rock, in his first year's work; yet he gives no intimation of any particular mode of fixing them, but the common way with lead: and the stump of one of the great irons of Mr. WINSTANLEY's, that was cut out in the course of the work of the summer 1756, was fixed in that manner; but we remarked, that the low end of this bar or stanchion was a little club-ended, and that the hole was somewhat under-cut; so that, when the lead was poured in, the whole together would make a sort of dovetail engraftment: however, when these irons, by great agitations became loose, and the lead yielded in a certain degree, they would be liable to be drawn out; as the orifice by which they entered, must have been large enough to receive the iron club.—Mr. RUDYERD's method, therefore, of keying and securing, must be considered as a material accession to the practical part of Engineering; as it furnishes us with a secure method of fixing ring-bolts and eye-bolts, stanchions, &c. not only into rocks of any known hardness; but into piers, moles, &c. that have already been constructed, for the safe mooring of ships; or fixing additional works, whether of stone or wood.

40. IN this way, by building *stratum super stratum*, of solid squared oak timber, which was of the best quality\*, Mr. RUDYERD was enabled to make a solid basement of what height he thought proper: but in addition to the above methods, he judiciously laid hold of the great principle of Engineering, that *WEIGHT is the most naturally and effectually resisted by WEIGHT*. He considered, that all his joints being pervious to water, and that though a great part of the ground joint of the whole mass, was in contact with the rock, yet many parts of it could not be accurately so; and therefore, that whatever parts of the ground joint were not in perfect contact, so as to exclude the water therefrom, though the separation was only by the thickness of a piece of post-paper, yet if capable of receiving water in a fluid state†, the action of a wave upon it edgewise, would upon the principles of Hydrostatics, produce an equal effect towards lifting it upwards, as if it acted immediately upon so much area of the bottom, as was not in close contact.

41. THE more effectually therefore to counteract every tendency of the seas to move the

\* It is said that all the timber used in this building was winter felled.

† When water is received into the pores of wood or stone and other solid bodies, I do not consider it as in a state of fluidity.

building, in any direction, he determined to interpose strata of Cornish Moor-stone between those of wood; and accordingly having raised his foundation solid, two courses above the top of the rock, he then put on five courses, of one foot thick each, of the Moor-stone\*. These courses were as well jointed as the workmen of the country could do it; to introduce as much weight as possible, into the space to contain them: they were however laid without any cement; but it appears that iron cramps were used to retain the stones of each course together, and also upright ones to confine down the outside stones; for though Mr. RUDYERD makes no mention of the cramps, I learnt this circumstance by conversing with a person actually employed in the preparation of the stone; as will be more fully stated hereafter.

42. WHEN five feet of Moor-stone were laid on, which according to the dimensions would weigh 120 tons; he then interposed a couple of courses of solid timber as before; the use of which was plainly for the more effectual and ready fastening of the outside uprights to the solid, by means of Jag-bolts†, or screw-bolts; and that these bolts might the more effectually hold in the wood, in every part of the circle (which could not be the case with timbers lying parallel to each other, because in two points of the circle opposite to each other, the timbers would present their ends towards the bolt) he encompassed those two courses with circular, or what is technically called compass timbers, properly scarphed together, and breaking joint one course upon the other. We must not however suppose, that these courses were composed wholly of circular timbers to the center, but that the circles of compass timbers on the outside, were filled up with parallel pieces within; and that the compass timbers were, in the most favourable points, jag-bolted to the interior parallel pieces.

The two uppermost courses, after clearing the rock, and before the five Moor-stone courses came on, were furnished with compass timbers, as well as some others below, which are also distinguished in Plate No. 6, exhibiting the orthographical elevation and section beforementioned of Mr. RUDYERD's Lighthouse, as it stood antecedent to its demolition by fire in the year 1755.

The two courses of wood above the Moor-stone courses beforementioned, terminated the entire solid of the basement; for a Well Hole was begun to be left upon these courses for stairs in the center, of six feet 9 inches in the square; and hereupon was fixed the entry door, or rather, one course lower, making a step up, just within the door; in consequence of this, the entire solid terminated about nine feet above the higher side of the base, and 19 feet above the lower side thereof‡.

The detached sketch Fig. 2, Plate No. 6 gives the plan of the five Moor-stone courses included in the entire solid, compiled from old working draughts, that appear to have been given out by Mr. RUDYERD during the course of the work, for forming and fixing these courses: the continued lines represent the joints of course No. 1; and the dotted lines, those of course No. 2, which shew how they broke joint upon one another: and the courses being alternately of these different figures, they would mutually break joint in the same manner.—In the original drawings, they were represented by black lines and red lines.—From hence it appears, that though no cramps are represented, yet besides the mast in the center, there are ten holes of about two inches diameter each; eight of them forming an octagon round the center, and two more in two of the opposite stones that abut upon the mast: and I have no doubt, but that the use of those holes was for the passage of iron bars or bolts, which firmly laying hold of the two compass

\* In Mr. RUDYERD's print six courses of Moor-stone are exhibited in this place; but in reality there were but five, as many occasions of repair have afterwards evinced; which is a further argument, that the print was compiled from a design or sketches made before the building was erected.

† Jag or bearded bolts or spikes, are such as with a chissel have a beard raised upon their angles, somewhat like that of a fish-hook, so that when driven forcibly into the wood, those beards, by laying hold, oppose their being drawn out again.

‡ The difference in the declivity of the base from that mentioned § 84 is to be attributed to the difference betwixt the original design and the execution.

courses under the Moor-stone, then passing through the five Moor-stone courses, and lastly through the two compass courses above the Moor-stone, would, besides the upright cramps, be a further means of tying all those nine courses firmly together as one solid; that solid being firmly tied by the trenails to the courses below, and those ultimately to the branches. This mode of binding appears still the more probable, as in Mr. RUDYERD's copper-plate representation, there is the appearance of iron bars proceeding through all the courses of stone, and to the termination of the solid at the store-room floor; but of these I find no traces either in the said drawings, or the building above the entire solid, further than has been already described.

43. IN Mr. WINSTANLEY's house, the entry was from the rock into an internal staircase, formed in the casing mentioned in the work of the 4th year, upon the S. E. side; he therefore needed only a few external steps, as shewn in Plate No. 5. But Mr. RUDYERD's entry door, being full eight feet above the highest part of the rock, he would consequently need a ladder. This he made of iron of great strength; and being open, whenever the seas broke upon this side of the house, they readily found their passage through, without making any very violent agitation upon it.

44. THE two compass courses terminating the entire solid, having been established, as already mentioned, he again proceeded with five Moor-stone courses; of which Fig. 3 is the plan, Plate No. 6, nearly the same as the former; allowing for the necessary difference, resulting from there now being a central well hole for the stairs, and a passage from the entry door, as described, to the well hole: this passage was 2 feet 11 inches wide, and as it appears, took up the whole height of the five courses. The weight of these five courses, according to the dimensions, amounted to 86 tons.

He then again proceeded with two compass courses, covering the door head and passage, so as now to leave no other vacuity, than the well hole; and upon these he laid four Moor-stone courses\*, the weight of which amounted to 67 tons. He then proceeded with two compass courses, and after that, with beds of timber cross and cross, and compass courses interposing; and last of all, with one compass course, upon which he laid a floor over all, of oak plank of three inches thick, which made the floor of the store-room.

45. THE height of this floor above the bottom of the well, was near 18 feet; above the foot of the mast 33 feet; above the rock on the higher side 27 feet; and above the foot of the building on the lower side 37 feet. In all this height, no cavity of any kind was intended for any purpose of depositing stores, &c.—From the rock to the bottom of the well, all was solid, as we have shewn; but as the building increased in height, and consequently was more out of the heavy stroke of the sea, a less degree of strength and solidity would be equivalent to the former, and therefore admit of the convenience of a staircase within the building, with a passage into it: which last, being made upon the east side, would be withdrawn from the heavy shock of the seas from the south-west quarter, and the rock being there highest, the ascent by the iron stair upon the outside, would be the least; the whole therefore to the height of the store-room floor, as abovementioned, having been made with all possible solidity, was denominated *the solid*.

46. THE height of Mr. RUDYERD's store-room floor, was fixed as high as the floor of Mr. WINSTANLEY's state-room, which was over his store-room†: and as many were doubtless still living who had seen and examined Mr. WINSTANLEY's Lighthouse, during the four years that it stood in a finished state; and as in that time there would be an opportunity of knowing from experience, to what height the unbroken water of the waves mounted in bad weather; we may very well suppose, that Mr. RUDYERD regulated the height of his solid from that information.

\* Mr. RUDYERD's design shews five courses; but this is clearly a mistake, as might be seen at any time, by counting them in the staircase.

† See § 24 and Plate No. 5.



47. WE have already seen, that the two compass courses of wood, which capped the first bed of moorstone, and terminated the entire solid, were forcibly screwed down by ten large iron bars or bolts to the beds of timber below the moorstone, and these by the trenails and branches to the rock. We must suppose this precaution to have been taken, to prevent any derangement from the heavy strokes of the sea in storms and hard gales, which were liable to happen in the very finest part of the season, before there was any proper opportunity of connecting the upper part of the work with the lower, by means of the upright timbers, that were to form the outside case; because, till the work was brought to that height, there could be no proper means of beginning to fix them: and as we do not find any traces or mention of binding the upper courses with the lower, after the staircase was set forward; we must suppose that the outside casing had been then begun from the rock, and carried on progressively, so as to become a bond of the upright kind: for, all such timbers as were high enough, having been screwed fast to the compass courses, would be thereby secured to the lower courses; otherwise, from what I have myself experienced of the situation, I should have expected, that whenever the two courses of compass timber were put upon the second bed of moorstone, if a hard gale should have come on at South-West, it would not only have lifted up and carried away the timber beds, but possibly would have deranged the moorstone courses; notwithstanding the upright cramps to the outside stones.

48. THE solid being in this manner completed, the upper part of the building comprehending four rooms, one above another, was chiefly formed by the outside upright timbers; having one Kurb or circle of compass timber at each floor, to which the upright timbers were screwed and connected; and upon which the floor timbers were rested. The uprights were also jag-bolted and trenailed to one another, and in this manner, the work was carried on to the height of 34 feet above the store-room floor; and there terminated by a planking of three inches thick, which composed the roof of the main column, as well as served for the floor of the lantern, and of the balcony round it.

49. THUS the main column of this building consisted of one simple figure, being an elegant frustum of a cone, unbroken by any projecting ornament, or any thing whereon the violence of the storms could lay hold; being, exclusive of its sloping foundation, 22 feet 8 inches upon its largest circular base; 61 feet high above that circular base; and 14 feet 3 inches in diameter at the top: so that the circular base was somewhat greater than one-third of the total height, and the diameter at top was somewhat less than two-thirds of the base at the greatest circle.

50. THE junction of the upright timbers upon each other, was by means of Scarfs, as they are technically called in ship-building and carpentry; that is, the joining of timbers end to end by overlapping. The timbers were of different lengths from 10 to 20 feet, and so suited, that no two joinings or scarfs of the uprights might fall together. The number of uprights composing the circle was the same from top to bottom; and their number being 71, their breadth at the bottom would be one foot nearly; their thickness there was 9 inches; and as they diminished in breadth towards the top, they also diminished in thickness. The whole of the outside seams was well caulked with oakum, in the same manner as in ships; and the whole payed over with pitch, consequently upon a near view, the seams running straight from top to bottom, in some measure resembled the fluting of columns; which in so simple a figure, could not fail to catch the attention of the beholder, and prove an agreeable engagement of the eye.

The whole of the building was indeed a piece of Shipwrightry: for it is plain from the preceding account, that the interposed beds of moorstone had nothing to do with the frame of the building, it being entire and complete exclusive thereof: the beds of moorstone could therefore only be considered in the nature of ballast, and amounted, from what has been before stated in the whole, to the weight of above 270 Tons.

51. ALL the windows, shutters and doors were composed of double plank, cross and cross, and clinked together; which falling into a rabbet, when shut, their outside formed a part of the

general surface, like the port-holes in a ship's side; without making any unevenness or projection in the surface.—There were however, two projecting parts terminating this frustum; one at the top, and the other at the joining with the rock; the utility of which seems to render them indispensable. They were each of them a projection of about 9 inches. The top projection, which is in the nature of a cornice, consisted of a simple bevil, and the use of it was very great; for in time of storms and hard gales of wind, when, according to the accounts of Mr. WINSTANLEY's building, the broken sea rises to a far greater height than the whole structure, it would be likely to break the windows of the lantern, unless there was something to throw it off, as their use does not admit of any defence by shutters. Therefore Mr. RUDYERD applied this simple cornice, judging it sufficient to have the effect of throwing off the sea in time of storms; and yet not of so much projection, as that the sea at the height of 71 feet above the foot of the building could have power enough to derange it.

The bottom projection, which has been called the Kant, and which fills up the angle formed between the uprights and the sloping surface of the rock, so as to guard the foot of the uprights from that violence of action which the waves naturally exert when driven into a corner, was certainly a very useful application: but whether it was originally constructed by Mr. RUDYERD himself, or was applied some time after, upon finding a want thereof, is at present uncertain.—I am rather inclined to think the latter, and that for two reasons: First, there is nothing of the kant shewn in Mr. RUDYERD's print of the building; the feet of the uprights being shewn as applied to the naked steps, both in section and elevation, without any thing of the kant; but as there were in reality many other deviations, I am more strongly inclined to think it was not there, upon the first completion, for the second reason; that is, because the iron stanchions or branches, that were let into the rock by way of confining the kant in its place, were not fixed into the rock in the method of Key and Dovetail, as Mr. RUDYERD had done all his principal and original branches; but were fixed in with club ends, in the way of Mr. WINSTANLEY's irons: whereas a workman versed in Mr. RUDYERD's method, would not only find it much more firm, but even more easy in the execution, than the old method.

52. UPON the flat roof of the main column, as a platform, Mr. RUDYERD fixed his lantern, which was an octagon of 10 feet 6 inches diameter externally. The mean height of the window frames of the lantern above the balcony floor, was nearly nine feet, so that the elevation of the center of the light above the highest side of the base was 70 feet; that is, lower than the center of Mr. WINSTANLEY's second lantern by seven feet; but higher than that of his first by 24 feet.—The width of Mr. RUDYERD's lantern was however nearly the same as that of Mr. WINSTANLEY's second: but instead of the towering ornaments of iron work, and a vane that rose above the top of the cupola no less than 21 feet, Mr. RUDYERD judiciously contented himself with finishing his building with a round ball, of 2 feet 3 inches diameter, which terminated at three feet above the top of his cupola. The whole height of Mr. RUDYERD's lantern, including the ball, was no more than 21 feet above his balcony floor; whereas that of Mr. WINSTANLEY, including the iron ornaments, was above forty.

The whole height then of Mr. RUDYERD's Lighthouse, from the lowest side to the top of the ball, was 92 feet, upon a base of 23 feet 4 inches, taken at a medium between the highest and lowest part of the rock that it covered.

53. IN the elevation of this building, contained in plate No. 6, the rock is represented at the low water, as seen from the South, in the manner I found it in the year 1756; to which, the present plate of the elevation of his Lighthouse is adapted, from the best documents concerning it that have come into my hands.

A shews the rock.—B the landing place.

aa the steps or flats to which the rock was reduced.—bb the branches.—cc, &c. floors of wood laid lengthwise of the steps.—dd floors laid crossways of the same.—ee courses of com-

pass timber.—D five courses of moorstone, which with two courses of compass timber marked E completed the entire solid, to the top of which led

F the iron ladder to G the entry door, and through GH the entry or passage into—HI the well-hole for the staircase.—KL the mast.—M five courses of moorstone, the height of which composed the entry or passage.

N two beds of compass timber, making good the passage to the stairs.

O four beds of moorstone, capped with two beds of compass timber, after which succeeded courses of timber alternately cross and cross, with compass courses interposed as shewn in the section.

PQ shew the upright timbers, as they appeared externally, being 71 in number.

pq the same in the upright section.

I the store-room floor, and R the door of the store-room; which was so much further to the North than the entry, that when casks and stores were drawn up perpendicularly by a tackle, suspended from above, they would clear the iron ladder.

S the state-room.—T the bed-chamber.—V the kitchen.—W the balcony.—X the lantern.—Y the lantern door into the balcony; and—Z the cupola and ball.

ff four curved pipes for venting the smoke from the candles in the lantern.

g the top of the copper funnel, which passed through the lantern, from the kitchen fireplace which was of brick.

h the upper bevil, or projection by way of cornice for throwing off the sea, to prevent it from breaking the lantern windows in time of storms; which was necessary, though the panes were of ground Glass, on account of strength.

i knees to strengthen the junction of the uprights with the balcony floor, and also in part to support the weight of the lantern.

kkk the original kirbs of compass timbers to form the uprights to a circle, and support the weight of the floors.

mmm Kirbs applied of late years for strengthening the frame of the building.

nn the kant at the foot of the uprights, and oo one of the stanchions by which the kants were fastened down.

54. SUCH a platform as the balcony round the lantern was absolutely necessary, on account of cleaning the outside of the windows; which gather a saline incrustation upon them, every storm and hard gale of wind; and the rails not only served the purpose of preventing persons from tumbling over, but were of use in hoisting the flag, as a signal to the shore, that something was wanted. This is sufficiently explained by Plate No. 5: but the flag-staff was not always in one fixed place, as there represented; as it could occasionally be lashed to the most proper part of the rails for its exhibition to the shore; and to suit the wind, so as that the flag might fly clear of the building.

Also instead of any cranes as shewn by Mr. WINSTANLEY, a pair of tackle blocks were occasionally, when wanted, hooked to the hand-rail of the balcony, and taken in when done with; for there was little chance of getting any thing into the house, except when a boat could lie in the Gut, and then it might be landed directly into the store-room.

The chink at p is the place where a part of a chain, apparently one of Mr. WINSTANLEY's crane chains, was jammed in so fast on the destruction of that Lighthouse, that it remained so during the whole continuance of Mr. RUDYERD's Lighthouse, and was shewn as one of the curiosities of the place.

55. I HAVE endeavoured to describe this building with all possible minuteness, because it affords a great, and a very useful lesson to future Engineers. We are sure that a building such as Mr. WINSTANLEY's, was not capable of resisting the utmost fury of the sea; because, in four years after its completion, it was totally demolished thereby: but Mr. RUDYERD's building having sustained the repeated attacks of that element in all its fury, for upwards of 46 years after



its completion; and then being destroyed, not by water, but by fire; we must conclude, it was of a construction capable of withstanding the greatest violence of the sea in that situation. And by withstanding it there, this Lighthouse proves the practicability of a similar erection in any like exposure in the known world: for, having attentively read and considered what is contained in the respective voyages of ANSON, BYRON, COOK, and PHIPPS, the most scientific navigators that modern times have produced, I do not find in all their accounts, such an exposure to the sea's uttermost violence, as at the Edystone Rocks.

56. Mr. RUDYERD informs us, as abovementioned, that a light was put up in this building the 28th July, 1708, and that it was completely finished in 1709\*. The means of exhibiting this light, would have been not only curious, but useful, had it been handed down to us. The best information that I have been enabled to procure upon this point is, "that a light was exhibited from the house in a lantern, that was raised upon eight fir Balks, which butted upon the solid, and were weather-boarded with deal."—At this time we must suppose that the solid was completed; and, in a great part, its exterior casing also; but that this casing was not got much above the solid: if therefore those eight pillars were raised, so as to be capable of hoisting a light above the floor of the third room; then, in the course of that summer, they might very well perfect the two low rooms, for lodging the lightkeepers, during the ensuing winter; and finish the two remaining rooms and principal lantern, the next season of 1709, as Mr. RUDYERD relates; that being the fourth and last summer of the progress of that work.

57. THE following anecdote has been related to me by such a variety of persons, that I cannot doubt of its having some foundation in truth, though no mention has been made thereof by Mr. RUDYERD. The relation will therefore I trust be acceptable to my readers, as it at once shews the great estimation in which this building has been held by foreigners, even such as were, at the very time, enemies of this country.

LEWIS the XIV. being at war with England, during the proceeding with this building, a French privateer took the men at work upon the Edystone rock, together with their tools, and carried them to France; and the captain was in expectation of a reward for the achievement. While the captives lay in prison, the transaction reached the ears of that monarch: He immediately ordered them to be released, and the captors to be put in their place; declaring, that though he was at war with England, he was not at war with mankind; he therefore directed the men to be sent back to their work with presents; observing that the Edystone Lighthouse was so situated, as to be of equal service to all nations having occasion to navigate the channel that divides France from England†.

58. I HAVE seen a paper in the hands of one of the present proprietors, upon which were put down the quantities of materials said to have been expended in the construction of this building: viz. 500 tons of stone; 1200 tons of timber; 80 tons of iron, and 35 tons of lead; and of re-nails, screws, and rack-bolts 2500 each‡.

\* This is further ascertained by the following extract from the preamble of an act of the 8th of Anne, chap. 17.

"And whereas the said Master, Wardens, and Assistants (of Trinity House) having a due regard to the safety and preservation of the shipping and navigation of this kingdom, did soon after the passing of the said act, (8th of Anne, chap. 20.) cause the said Lighthouse to be begun, and to be rebuilt; and by the great care and diligence of the persons employed therein, the said work was carried on with such expedition, that a light *useful for shipping* was placed therein on the 28th July 1708; and the said Lighthouse hath since, with much hazard and difficulty, and at a very great expence been fully built and completed, to the great satisfaction of the flag officers and commanders of her majesty's fleet and ships of war, and of all others concerned in trade and navigation."

† Mr. RUDYERD remarks upon the face of his print, that "to expedite the work and to protect the workmen, these four men of war, at sundry times, were appointed to this station, viz. 1st, The Roebuck of 42 guns.—2d, The Charles Galley of 36.—3d, The Swallow's Prize of 32.—4th, The Albrow of 24." Which appointment was probably in consequence of the accident above related.

‡ This must be supposed the account of rough materials, otherwise the stone and timber must greatly exceed the real quantity.

## CHAP. IV.

CONTAINING SUBSEQUENT TRANSACTIONS AND OCCURRENCES FROM THE  
FINISHING MR. RUDYERD'S LIGHTHOUSE, TO THE TOTAL  
DEMOLITION THEREOF.

59. FROM the time of finishing the Lighthouse in 1709, we have no further particulars till about the year 1715, when Captain LOVELL, the proprietor of the lease, under the Corporation of the Trinity House, beforementioned, being deceased, his property was sold at public biddings by a Master in Chancery, in consequence of a decree and directions from that court: when it was purchased by three persons, viz. ROBERT WESTON, Esq; RICHARD NOYES, Esq; of Grays Inn; and ——— CHEETHAM, Esq; an Alderman of Dublin. The agreement of the purchasers was to divide the leasehold property thus acquired into eight shares, of which Mr. WESTON had three, Mr. NOYES two, and Mr. CHEETHAM three.

60. THIS house, we are told, stood in no need of any material repairs for some years; but in or about the year 1723, defects were discovered, which required great attention: for now it was first observed, that some parts of the uprights were decayed at the but ends, by means of a small worm, which had eaten some inches into them, especially those on the lowest side of the house. Hereupon the gentlemen proprietors appointed Mr. JOHN HOLLAND, then a foreman shipwright in his Majesty's dock-yard at Plymouth, to survey and direct the repairs; which he very judiciously did, from time to time, till he was advanced to the office of assistant builder in Woolwich Yard: on which occasion, the overseeing and conducting of the repairs was transferred to a creditable shipwright at Plymouth dock; upon whose reports of the state of the building, from time to time, Mr. HOLLAND gave directions in what manner to proceed: but this not being so satisfactory to the proprietors, as when under the immediate inspection and direction of Mr. HOLLAND; and some considerable repairs being necessary in the year 1734, Mr. HOLLAND, by leave of the Lords Commissioners of the ADMIRALTY, was sent down to Plymouth to conduct the same.

This is the period when the structure of that edifice, and the defects it was liable to, became better understood; for one of the gentlemen principally interested, followed Mr. HOLLAND to Plymouth, and residing there a considerable time, made many observations in his visits to the building; and seeing how the works were carried on, formed such a plan for the future conducting of this structure, as might probably have preserved it for a number of years, against the attacks of those elements to which from its critical situation it was the most obviously exposed\*.

61. IN this place it may be proper to take notice of an experiment which was tried in 1734, to prevent the ill effects that might happen from the worm: and that was by covering the outsides of 15 pieces of the uprights, at the bottom of the house, with copper, and their insides with lead; and two pieces were covered entirely with copper, as high as the worm destroyed: but I

\* In this year Mr. HOLLAND made a very curious draught of the Lighthouse, in which every one of the outside upright timbers was distinctly represented; so that every one of them could numerically be referred to; and the places and nature of the scarring or joinings distinguished. This was done by supposing the whole of the uprights to be separated at one particular joint, from top to bottom; and then all the rest opened till they were brought into one plane: the figure thus formed would become a kind of Evolute of the surface of the whole building; and was peculiarly adapted to illustrate the experiments, reports and repairs that were then carrying on, and might from time to time thereafter be wanted or recommended: this draught distinctly represents the kant at the bottom; and hereby it was first known, that the real number of uprights was 71; and not 72 as had been before imagined.

am informed, this did not thoroughly answer expectation; for in 1744, one of those pieces that was entirely coppered, was taken out, and found to be worm-eaten\*.

62. THE latter end of 1744 after all the necessary repairs were finished, there happened a dreadful storm on the 26th September, which being from the East, tore away no less than 30 pieces of the uprights all together†; which in part made an opening into the store-room: this disaster however, by great exertion, was entirely repaired by the 14th December following, under the inspection and direction of Mr. JOSIAS JESSOP, then (and indeed until his death no more than) that species of foreman shipwright, called a Quarter-man in Plymouth dock. This person, whose modesty and ingenuity caused him to be deservedly respected by many, Mr. HOLLAND recommended to the proprietors to be their overseer, which they still rank among the eminent services he did them‡.

Mr. HOLLAND, who had been promoted to be King's Builder at Deptford Yard, continued his good offices to the time of his death, which happened not till the year 1752; and then the execution of the important office of repairing this building, was solely intrusted to Mr. JESSOP, who discharged his duty herein, with the greatest integrity, diligence and accuracy, till the calamity happened, which totally destroyed the building, and which could neither be foreseen nor avoided.

63. IT seems that for many years after the establishment of this Lighthouse, it was attended by two men only; and indeed the duty required no more; as the principal part of that, besides keeping the windows of the lantern clean (and in general the rooms) was the alternately watching four hours, and four hours, to snuff and renew the candles: each at the conclusion of his watch taking care to call the other and to see him on duty before he himself retired: but it happened, that one of the men was taken ill and died; and notwithstanding the Edystone Flag was hoisted, yet the weather was such for some time, as to prevent any boat from getting so near the rocks as to speak to them§.—In this dilemma, the living man found himself in an awkward situation; being apprehensive that if he tumbled the dead body into the sea, which was the only way in his power to dispose of it, he might be charged with murder; this induced him for some time to let the dead corpse lie, in hopes that the boat might be able to land and relieve him from the distress he was in.—By degrees the body became so offensive, that it was not in his power to get quit of it without help; for it was near a month before the attending boat could effect a landing; and then it was not without the greatest difficulty that it could be done when they did land. To such a degree was the whole building filled with the stench of the corpse, that it was all they

\* It will now seem that this experiment of plate copper (which I have from the best authority) that did not succeed in preventing and destroying the worm, is not easily to be reconciled with the present practice of sheathing ships bottoms therewith, which is held to be an effectual remedy, as being a poison to the worm: this we may however infer, that this, as well as many other good propositions, have been given up too hastily: for though here was a trial of 10 years, yet the practice was condemned as ineffectual upon a single instance. On consulting my scientific friends respecting this fact, ingenious reasons have been suggested, why the constant state of immersion that takes place in a ship's bottom, may more effectually convey the poison into the wood, than where it is forsaken by the sea every tide; and even that the strokes of the sea may at the Edystone be so great as to wash the poison out again from the wood, that in a situation of less violence could gradually and slowly insinuate itself; and probably something of this kind may have been the case: but on lately conversing with a very intelligent builder of one of his Majesty's yards, I am informed, that it is not uncommon for the timber of ships to be eat by the worm under the copper sheathing, where the joints have not been carefully closed; so that in fact it is not so much its being a poison, as the means of their total exclusion, by a coating that they cannot penetrate, that prevents their destroying the wood: we may therefore, rather impute the want of success in the year 1734, to their not being skillful to close the joints of the copper plates sufficiently compact.

† It was in this storm that Admiral BALCHEN was lost in the Victory.

‡ After the appointment of Mr. JESSOP, and in consequence of the numbers of uprights torn away in the storm of 1744, which enabled him to see further into the construction of the solid than had been known before; he made a still more accurate Evolute, and also a model of the Lighthouse, and it is principally from the measures of this Evolute, that I have compiled the present draught, Plate No. 6.

§ The signal, when any thing was wanted by the Lightkeepers, was to hoist a large flag upon a flag-staff from the balcony rails (as has been observed in the references to the Plates No. 5 and 6) on the leeward side, so as to be fully extended by the wind, clear of the building; which could easily be seen in moderate weather from the heights about Ram-Head: and that it might never be hung out in vain, it was a rule, that the person who carried the first notice to the agent at Plymouth, received from him half a guinea; the agent immediately on this proceeded to hire and send out a boat, to land, if possible, and at least to know what was wanted.



could do to get the dead body disposed of, and thrown into the sea; and it was some time after that, before the rooms could be got freed from the noisome stench that was left. This induced the proprietors to employ a third man; so that in case of a future accident of the same nature, or the sickness of either, there might be constantly one to supply the place.

This regulation also afforded a seasonable relief to the Lightkeepers; for ever since there were three, it has been an established rule, that in the summer, in their turns, they are permitted each to go on shore, and spend a month among their friends and acquaintance.

64. WHETHER the abovementioned two men, of which one died, were the two to which the following account that I found very current in the country, referred; or it was a couple preceding them, is now uncertain: but a boat landing there with visitants of curiosity (as not unfrequently happens in the summer season) after examining the place and structure; they observed to one of the men, how very comfortably they might there live in a state of retirement. "Yes," says the man, "very comfortably, if we could have the use of our tongues; but it is now a full month since my partner and I have spoke to each other." The appointment of three has most likely put a stop to this piece of unseasonable taciturnity; for though we have seen it is possible to find two, yet it is scarcely probable there should be found three together of this mind\*.

Being now upon the chapter of anecdotes, I will proceed to give one, that shews how very different the ideas of mankind are concerning the nature of confinement. It happened in some one of the last years of the continuance of the late building; and I was told the story by the very skipper who bore a part in the conversation. Says the skipper to a shoemaker in his boat, who he was carrying out to be a lightkeeper; How happens it, friend Jacob, that you should chuse to go out to be a lightkeeper, when you can on shore, as I am told, earn your half crown and three shillings a day in making leathern hose†; whereas the lightkeeper's salary is but £. 25 a year, which is scarce ten shillings a week? Says the shoemaker, I go to be a lightkeeper because I don't like confinement! After this answer had produced its share of merriment; he at last explained himself, by saying, that he did not like to be confined to work.

65. WE now come to the last awful scene, containing the fatal catastrophe of this celebrated building.

On the 22d of August 1755 the workmen returned on shore, having finished all necessary repairs of that season: between which time and the 2d of December following, the attending boat had been off several times to the Edystone, and particularly on the 1st of December, and had landed some stores, when the lightkeepers made no manner of complaint; and said all was right, except that one or two of the bricks in the kitchen fire-place, had been loosened by a late storm‡.

66. WHAT in reality might occasion the building's first catching fire, it has never been possible fully to investigate; but from the most distinct account, it appears to have commenced in the very top of the lantern, that is, in the cupola.

If I might hazard conjectures, I would suppose, that the whole building being of wood, and the heat of the candles in the lantern considerable§, and this repeated every night for between 40 and 50 years together, we may well suppose the wood above them, and particularly the lining of thin boards that supported the uppermost cover of sheet lead, to be brought into a perfect state of dryness and inflammability; and this of course being covered with a thick crust of soot, col-

\* It is very possible I might have passed over this anecdote in silence, had it not been alluded to in one of the speeches of Lord NORTH, in the time of the late war, where he gives this as an instance how the public service is liable to be obstructed by private dissensions: however just this remark, yet as it may be a satisfaction to the maritime part of the public to know it; I beg leave to say, I never heard that this line of the public service was ever intermitted or obstructed by this or any dissensions among the parties themselves.

† Leathern pipes so called.

‡ This is another proof of the violent agitation this building was put into by storms and hard gales of wind.

§ Viz. 24 candles burning at once, five whereof weighed two pounds, and it was usual to go into the lantern to snuff them every half hour.

lected by receiving the smoke of the candles, the whole together would become in reality a mass of tinder and matches. Now if we can suppose it possible for a single spark to fly from one of the candles, and lodge itself in this mass of combustible matter, the consequence is obvious: or, if we suppose, that in length of time, the copper funnel in passing the cupola, had been corroded by the salts of the sea falling into it in storms, and also by the pit-coal soot from the kitchen fire, so as to open a hole into the upper part in the cupola, by which, a spark might issue from the fire below, the consequence would be the same\*. But whether either of these may be esteemed a probable account of the origin of the fire, or not, it is certain, that when the lightkeeper then upon the watch (about two o'clock in the morning of the 2d of December) went into the lantern as usual to snuff the candles, he found the whole in a smoke; and upon opening the door of the lantern into the balcony, a flame instantly burst from the inside of the cupola: he immediately endeavoured to alarm his companions; but they being in bed and asleep, were not so ready in coming to his assistance as the occasion required.—As there were always some leathern buckets kept in the house, and a tub of water in the lantern; he attempted as speedily as possible to extinguish the fire in the cupola, by throwing water from the balcony with a leather bucket, upon the outside cover of lead: by this time, his comrades approaching, he encouraged them to fetch up water with the leather buckets from the sea; but as the height would be at a medium full 70 feet, this, added to the natural consternation that must attend such a sudden and totally unexpected event, would occasion this business of bringing up water, at the best to go on but slowly. Meanwhile, the flames gathering strength every moment, and the poor man, though making use of every exertion, having the water to throw full four yards higher than his own head, to be of any service; we must by no means be surprised, that under all these difficulties, the fire, instead of being soon extinguished, would increase; and what put a sudden stop to further exertions, was the following most remarkable circumstance.

As he was looking upward with the utmost attention, to see the direction and success of the water thrown; on which occasion, as physiognomists tell us, the mouth is naturally a little open; a quantity of lead, dissolved by the heat of the flames, suddenly rushed like a torrent from the roof, and fell, not only upon the man's head, face and shoulders, but over his cloaths; and a part of it made its way through his shirt collar, and very much burnt his neck and shoulders: from this moment he had a violent internal sensation, and imagined that a quantity of this lead had passed his throat, and got into his body. Under this violence of pain and anxiety, as every attempt had proved ineffectual, and the rage of the flames was increasing, it is not to be wondered that the terror and dismay of the three men increased in proportion; so that they all found themselves intimidated, and glad to make their retreat from that immediate scene of horror, into one of the rooms below: where they would find themselves precluded from doing any thing; for had they thrown down ever so much water there, it could not have extinguished what was burning above them; nor indeed, produce any other effect, than that of running down into the rooms below; and from thence finally through the staircase, back again into the sea: they seem therefore to have had no other resource or means of retreat, than that of retiring downwards from room to room, as the fire advanced over their heads.

67. HOW soon the fire was seen from the shore, is not very certain; but early in the morning it was perceived by some of the Cawsand fishermen†, and intelligence thereof given to Mr. EDWARDS of Rame in that neighbourhood, a gentleman of some fortune, and more humanity. This prompted him immediately to send out a fishing-boat and men, to the relief of the people he supposed in distress upon the Edystone‡.

\* This supposition is not without grounds, as the lightkeepers, after the accident, declared, that the fire broke out from the chimney or funnel into the cupola; but were not believed then, as the whole of it that passed through the lantern was of copper.

† Cawsand Bay is a capacious bay within the confines of Plymouth Sound; it lies just within the Sound, on the west side; the southernmost point of this bay is Point Penlee, which is also the extreme point of Plymouth Sound on the west side; and the two fishing towns of Kingston and Cawsand are situated at the bottom of the bay. See the Map, No. 2.

‡ I am informed by my esteemed friend Dr. MUNOZ of Plymouth, that the philanthropy of this worthy gentleman on this occasion, cost him his life; for his exertions gave him so violent a cold as to bring on complaints of which he shortly after died.

The boat and men got thither about ten o'clock, after the fire had been burning full eight hours; and in this time, the three lightkeepers were not only driven from all the rooms, and the stair-case, but to avoid the falling of the timber, and red-hot bolts, &c. upon them, they were found sitting in the hole or cave on the East side of the rock (See Plate No. 6 Letter q, also Plate No. 14 Letter X) under the iron ladder, almost in a state of stupefaction; it being then low water.

68. AT this time the wind was eastwardly, and did not blow very fresh; but just hard enough to make a landing upon the rock, at the proper landing-place (which is on the East side) quite impracticable, or attended with the utmost hazard. It therefore became a difficulty, how the men were to be taken off; for the ground swell upon the West side produced so great a surf upon the sloping surface, that no boat could attempt to land there. They however fell upon the following expedient: having a small boat with them, they moored their principal boat by a grappling to the westward; but as near the rock as they durst; and then launching their small boat, they rowed it towards the rock, veering out a rope, which they had fastened to the large boat, till they got near enough to throw a coil of small rope upon the rock; which having been laid hold of by the men, they one by one fastened it round their waists, and jumping into the sea, they were towed into the small boat; and from thence delivered into the large one: and as they found that it was out of their power to do any further service, this boat hastened to Plymouth to get the men relieved. No sooner however were they set on shore, than one of them made off, and has never since been heard of: which would on the first blush induce one to suppose, there was something culpable in this man; and if it had been a house on shore one would have been tempted to suspect he had been guilty of some foul play; but the circumstance of its being a Lighthouse, situated so as to afford no retreat in the power of its inhabitants, seems to preclude the possibility of its being done wilfully; as he must know, he must perish, or be in extreme danger of so doing at least, along with the rest. I would therefore rather impute his sudden flight, to that kind of panic, which sometimes, on important occasions, seizes weak minds; making them act without reason, and in so doing commit actions the very reverse in tendency of what they mean them to have; and of which they have afterwards occasion to repent: but the man already described to have suffered so much by the melted lead, was sent to his own house at Stonehouse, a village near the place where they landed.

69. IT was not long after the alarm was made at Cawsand, that the dreadful news reached Plymouth; and as from the composition of the structure, it was thought that a considerable part of it might be saved, at least of the foundation, endeavours were not wanting for that purpose; for Mr. Alderman TOLCHER, the agent and collector of the duties, who was a perfect enthusiast for the welfare of the Lighthouse; and his son Mr. JOSEPH TOLCHER, immediately went out to sea; both gentlemen were ever, but then more than ever, indefatigable in their endeavours for its preservation. When they came there, alas! what could they do? There was no landing, except at the imminent hazard of their lives; and if landed, they could not do any thing. They could therefore only have the supreme mortification to behold, that after the rooms and all the upper works were totally destroyed, the fire was rapidly communicating itself into the solid; and there being many beds of solid timber above all the stone, their connexion with those below, by means of the mast and stairs in the well-hole, and by the upright timbers on the outside, would not suffer a doubt to remain, that after such a mass of fire was generated above, it would gradually communicate itself to the beds of timber interposed between those of Moor-stone, and by that means consume the whole.

70. THE late worthy Admiral WEST, who then lay with a fleet in Plymouth Sound, on hearing of the accident, immediately sent out a sloop properly manned, with a boat and an engine therein, which also carried out Mr. JESSOP the surveyor; this vessel also arrived early in the day on which the fire happened. In endeavouring to make a landing of the engine, on the West side, it being then about low water, the boat, men and engine were at once tossed upon the rock by a wave, which on its retreat left them thereon; and before the engine was got out of



the boat, another wave came, set them afloat, and swept them back again to their former situation: British Tars are not dismayed with small matters; however, this accident sufficiently taught them to be thankful for an escape with their lives; and to make no further attempt to land: yet they notwithstanding tried to play the engine from the boat; but the agitation of the sea near the rock was such, that they very soon broke the engine pipe; and so ended this well meant expedition, in a total disappointment.

71. THE only hopes that then remained, were from a great addition to the wind, which then blew; or a shift of wind to the S. W. quarter: for, the rocks being nearly perpendicular on the East side; and the seas being in some measure broken by the South Reef stretching on the East side of the House Reef, (see Plate No. 3.) it is only in hard gales of wind that the sea breaks in quantity, and bodily over the house reef from the East towards the West; whereas, the wind if only fresh at S. W. increases the ground swell, which is almost constant (more or less) from that quarter, to a degree that would infallibly have put out the fire: but if we are believers in Fate, we must suppose that this building had been destined to a total destruction: for the wind continued almost invariably at the same quarter, and with the same degree of strength; so that there was constantly sea enough to prevent all attempts to land, and yet not enough to cause the seas to break so high, and in such quantity as to put out the fire.

In the succeeding days, it was observed that the interposed beds of timber were sufficient to heat the Moor-stone beds red hot; and that the whole mass became one great body of red hot matter. Nor was it till the 7th of the same month, that the joint action of the wind, the fire and the seas totally completed the catastrophe so fatally begun; and then left no other evidence of the destruction they had made, than that the greatest number of the iron cramps and branches were left standing upright upon the rock.

72. WE will now return to the poor unfortunate man, who had received so peculiar an injury by the melted lead. His name was HENRY HALL of Stonehouse near Plymouth, and though aged 94 years, being of a good constitution, he was remarkably active considering his time of life: he had invariably told the surgeon who attended him (Mr. SPRY, now Dr. SPRY of Plymouth, who constantly administered the proper remedies to such burns and hurts as could be perceived) that if he would do any thing effectual to his recovery, he must relieve his stomach from the lead, which he was sure was within him: and this he not only told Dr. SPRY, but those about him, though in a very hoarse voice; and he also said the same thing to Mr. JESSOP, who went to see him several times during his illness, and who gave me this information. The reality of the assertion seemed however then incredible to Dr. SPRY, who could scarcely suppose it possible, that any human being could exist, after receiving melted lead into the stomach; much less that he should afterwards be able to bear towing through the sea from the rock; and also the fatigue and inconvenience from the length of time he was in getting on shore, before any remedies could be applied. The man did not shew any symptoms however of being either much worse, or of amendment, till the sixth day after the accident, when he was thought to be better: he constantly took his medicines, and swallowed many things both liquid and solid till the tenth or eleventh day; after which he suddenly grew worse; and the twelfth day being seized with cold sweats and spasms, he soon afterwards expired.

Mr. JESSOP was desired by Dr. SPRY to attend the opening of the body; but being averse to sights of that kind, he excused himself from seeing the operation; as did also the daughter of the deceased, and another woman who was in the house. On opening the stomach Dr. SPRY found therein, a solid piece of lead of a flat oval form, which weighed Seven Ounces and five drachms, and this he immediately shewed to the two women, and afterwards to Mr. JESSOP. I have also seen the piece of lead since in the hands of Mr. TOLCHER, and it appeared to me, as if a part of the coat of the stomach firmly adhered to the convex side thereof.

73. BY a letter of the 19th December, Dr. SPRY transmitted an account of this very singular

case to the Royal Society, inclosing the exact weight and figure of the lead; but that learned body thinking the circumstance very unlikely and extraordinary, and doubting the truth of it, the reading of the paper was deferred till a further elucidation was received.

As Dr. SPRY had on this occasion been deprived of the benefit of eye-witnesses; and supposing his character called upon, not only as a professional man, but as a man of veracity; he endeavoured to support himself by experiments of the same kind upon different animals.—He therefore tried what would happen by pouring melted lead down the throats of dogs and fowls, to the amount of, from six drachms to six ounces; and found that those animals survived the operation, till they were killed to extract the lead: and Dr. SPRY says, he kept one dog with lead in his stomach, with intent to try how long he might survive.

The account of these experiments is contained in a letter of the 30th January 1756, from Dr. SPRY, addressed to LORD MACCLESFIELD, then President of the Royal Society; and it was further corroborated by a letter from the late Dr. HUXHAM of Plymouth, F.R.S. to the late Sir WILLIAM WATSON, F.R.S. who speaks not only to the ingenuity and veracity of Dr. SPRY, but of his being himself eye-witness to the extraction of a lump of lead of near three ounces weight, from the crop of a cock, that previous to being killed, though he seemed dull, yet readily pecked and swallowed several barley-corns that were thrown to him\*.

Though the authenticity of this wonderful (and till this instance unheard of) capacity of animal bodies was thus investigated†; yet Dr. SPRY was still so unfortunate as to fall under a censure of a different kind; that of cruelty towards the animals, in trying the experiments mentioned.

For my own part I cannot but think that Dr. SPRY was somewhat hardly used: he attempted no experiments upon other animals, till he found his account disbelieved by the most eminent of his profession; his character therefore and future prospects in life were endangered, he being then a young gentleman of some expectations. What therefore was the comparison between the lives of a few dogs and poultry, to the loss of character of a man bred to a profession, upon his success in which, as depending upon the good opinion of others, must depend likewise that benefit and utility which he might be of to his fellow-subjects? Such however was Dr. SPRY's lot, that in establishing his abilities in his profession, he was then by some stigmatized with the imputation of inhumanity.

74. IT has been thought by many, that if the poor lightkeepers, when in the midst of their distress, had been possessed of reflection enough to have thrown out their combustible stores, such as chests of Candles, Coals, &c. there might have been a probability of saving the whole, or some part of the solid of the Lighthouse; in which case, the repair would have been ready and easy; and the following summer might have been sufficient for its reinstatement: but in my own opinion, the doing of this could not have retarded the progress of the fire a single hour; for, in the three upper rooms there was little more to burn than in the store-room, had it been emptied of stores; and the same communication by the uprights, would have taken place here, as above; and the store-room floor, being itself, and every thing underneath it, of wood, for a depth or thickness of between six and seven feet; and this open in the center by a square of above six feet, in which were included the stairs and the mast, there could be no want of communication for the fire, from the rooms to the solid, even exclusive of all the stores: nor can I conceive any thing within the reach of human art could have saved the building, even if the rock had been accessible; unless there had been time enough for shipwrights or carpenters to have been sent out with

\* Those that are further curious on this subject, will find a full account thereof in the 4<sup>th</sup> vol. of the Philosophical Transactions, page 477, wherein Dr. SPRY fully describes the complaints and method of treatment of his patient; and in the succeeding articles are other particulars above referred to.

† Though there is at present no doubt of the fact of the lead being taken out of the man's stomach after he had survived it 12 days; yet these experiments by no means prove, that it would not be instant death to the human species, in by far the greatest number of cases.

proper tools, before the fire had got so low as the store-room : then indeed it would have been very practicable to have cut the uprights quite round the building, where they were only a single thickness, as was the case above the store-room floor ; and by supporting the Saw-gate with wedges, the whole of the superstructure, together with the mast, might have been expeditiously severed from the solid : but even after this, under the circumstances beforementioned, it would have been very problematical, whether a battery of chain shot from a ship of war, carrying heavy metal, could have so speedily and effectually dispersed the superstructure so severed, as to have prevented its fragments from setting fire to the solid below : and to such a mass of combustibles, had the solid caught fire, a single fire-engine, or even two, which would be rather more than could have been worked upon the rock, with any degree of convenience, would have proved very inadequate.

Nothing therefore, as it seems, but a storm, or hard gale of wind at South-west, as already hinted, could have effectually put out the fire, so as to have saved any material part of the building, which, after a duration of forty-nine years from its commencement, was doomed to inevitable destruction, by an element, not so much as thought of as an Enemy ; or guarded against, as such, in its erection.



## BOOK II.

AN ACCOUNT OF PREPARATORY MATTERS TOWARDS BUILDING THE  
PRESENT LIGHTHOUSE UPON THE EDYSTONE ROCK WITH STONE.

## CHAPTER I.

CONTAINING THE PROCEEDINGS FROM THE DESTRUCTION OF MR.  
RUDYERD'S LIGHTHOUSE IN DECEMBER 1755, TO MR. SMEATON'S  
DEPARTURE FROM LONDON TO PLYMOUTH IN MARCH 1756.

75. THE Lighthouse happily effected by Mr. RUDYERD, having been totally consumed by fire in December 1755, as before related; and the Proprietors, having the remainder of a term therein of above half a century, they immediately applied themselves in the most strenuous manner towards the erecting of another Lighthouse in the place of that which had been, both for themselves and the public, so unfortunately destroyed. In this however there arose some difficulties; for a space of 30 years having elapsed, since the purchases of shares by the three families which I have mentioned, § 59, in this interval a number of changes (as might reasonably be expected) had happened in the property. Some shares of the Lighthouse having been devised by will to be divided amongst children, and settlements on marriage having taken place with respect to other shares thereof; the claimants therefore were now become numerous. The whole interest of the third person mentioned, Mr. CHEETHAM, being three shares, was however at this time vested in a Mrs. HOPFLEGGER, they having been settled upon her in marriage; and on this account, the principal impediment occurred; for without the expenditure of a considerable sum of money, such as it might be supposed three-eighths of the erection would cost, the whole of her shares could not be valued at any thing; no duties being payable while no light was exhibited\*: and as her estate in the Lighthouse was only for life, it was not to be expected that she should advance a sum of money, from the expenditure of which the greatest benefit might probably devolve upon her successors. In consequence of this circumstance, an early application to Parliament took place, and an act was obtained enabling Mrs. HOPFLEGGER to sell so much of her property and interest in the Lighthouse, as would pay for that share of the building she was to retain.

On the other hand it may be reckoned among the fortunate circumstances attending this Catastrophe, that the three-eighths purchased by the WESTON'S, not only remained in that family, but continued so far united, that, though separately taken they were in different branches, yet the executive part for the whole of these shares was in one person: and as at this time the claimants under the NOYES'S family were more than a dozen in number, it still more fortunately happened, that ROBERT WESTON, Esq; from his having for years past taken a most discreet part, respecting the management of this property, and having so considerable a share in his own person, had the utmost trust and confidence reposed in him by the whole body of the proprietors: but it may be reckoned among the most fortunate of all the circumstances for the future undertaking, that this gentleman was not more remarkable for his strict integrity, than for his discernment and universal Philanthropy.

\* An early piece of justice, which indeed has always marked the Proprietors, appeared by their advertisement in the Gazette, and other newspapers, in the first fortnight after the accident happened, importing that the duties had ceased till a fresh exhibition of a light; and that the money which had been, or should be paid by ships, after the demolition, would be returned by the agents who received it.

He considered that this was not a work proper to be advertised ; or put into the hands of a general undertaker in the building way ; and that it would not be better for the ornaments to be derived from the five Orders ; that it was a work of a very peculiar kind ; and that to reinstate it, would not so much require a person who had merely been bred, or had even rendered himself eminent, in this, or that given profession ; but rather one who from natural genius had a turn for contrivance in the mechanical branches of science ; and that such a one would be the most likely person to take into consideration the peculiarities, the advantages, and disadvantages of the situation, as well as other circumstances : in short, that it required a person who would not stand in need of being led by the actual execution of a similar performance ; but who solely from the nature of the thing, would be likely to find out the proper methods of executing a building of the like kind with that, which had approved itself upon an experience of near 50 years ; such a person being the most likely to discern how far the late building was defective, how far these defects were capable of a remedy ; and what improvements could be made upon the former construction.

76. IN this view Mr. WESTON laid aside those prejudices of the ignorant, who consider the Royal Society as a body of theoretic Men only, having nothing amongst them practical, or applicable to the real business of human life ; he well knew that though in a multitude there might be many of that denomination ; yet that there were also many real artists in this body : and that since its institution by King CHARLES the Second, the most important inventions, applicable to the greatest purposes of human life, had originally sprung from the joint labours of ingenious men, either actually members, or connected by correspondence with those who were so : and this without a view to any particular emolument or reward.

Under these circumstances, Mr. WESTON applied to the late Earl of MACCLESFIELD, the then President of the Royal Society ; a nobleman scarce known to him, but by public character. On communicating the object of his visit, Lord MACCLESFIELD told him, that there was one of their Body whom he could venture to recommend to the business ; yet that the most material part of what he knew of him was, his having within the compass of the last seven years, recommended himself to the society by the communication of several mechanical inventions and improvements ; and though he had at first made it his business to execute things in the instrument way (without having ever been bred to the trade) yet on account of the merit of his performances, he had been chosen a member of the society\* : and that for about three years past, having found the business of a Philosophical Instrument Maker not likely to afford an adequate recompence ; he had wholly applied himself to such branches of mechanics, as he (Mr. WESTON) appeared to want ; that he was then somewhere in Scotland, or in the north of England, doing business in that line : that what he had to say further of him was, his never having known him undertake any thing, but what he completed to the satisfaction of those who employed him ; and that Mr. WESTON might rely upon it, when the business was stated to him, he would not undertake it, unless he clearly saw himself capable of performing it.

This kind of character which the noble Earl was pleased to honour me with, proved fully satisfactory to Mr. WESTON, and as his Lordship did not know how to direct to me, he learnt from him, that as I was well acquainted with Mr. B. WILSON an eminent painter in Great Queen-street, he would probably get a direction to me from that gentleman.

Upon this, he immediately applied to Mr. WILSON, who undertook to write to me (being then in Northumberland) which he did very laconically, signifying that I was made choice of as a proper person to rebuild the Edystone Lighthouse : this was early in the month of January 1756. —I had at that time, but barely heard that the Edystone Lighthouse was destroyed by Fire ; and having seen a popular print of it, I understood that it was a building very critically placed out at sea, upon a single rock : but as I had no doubt that its foundation part at least, was built with Stone, though its upper works had the appearance of timber, I could not readily conceive how it could be totally destroyed. I concluded therefore, that the object was to repair or restore the Upper Works : and therefore I received the call without joy, or indeed much emotion of

\* Mr. SHALTON was chosen Fellow of the Royal Society 15 March 1753.

any kind; concluding, as most public works of consequence were undertaken upon advertisements, the meaning was, that I should return to London to give in my proposals along with other candidates.

I therefore returned my friend for answer, that I supposed it was meant I should go back to town in order to form a scheme, which if it had the good luck to be thought preferable to that of others, I was to be employed in the Repair of the building: if this was the case, I had engagements and prospects before me, that I could not leave upon any uncertainty; but that if I was absolutely chosen to this business, I should think it so great an honour done me, that in one month I would divest myself of all other engagements, and attend the gentlemen in town. To this I received an answer from my friend, even more laconic than before. That it was a total demolition, and that as NATHAN said unto DAVID "*Thou art the Man.*"

77. HAVING acquitted myself of the business in which I had been engaged in the North, I arrived in London the 23d February 1756; and the next day, agreeable to a message I had received for that purpose, waited on ROBERT WESTON, Esq; till then totally unknown to me. The hours spent in this interview, were taken up in my attention to a relation of the nature of the structure of the former Lighthouses of Mr. WINSTANLEY and Mr. RUDYERD; and in examining several plans, models and drawings in Mr. WESTON's possession, that referred thereto.—I was till then, I may say, almost a total stranger to those structures and their situation (which indeed by the description now given of them appeared very formidable) as I never happened to have been in those parts; and a mechanical description of them never fell in my way: but from the information now given me, I thought a little time and study would make me sufficiently master of the subject, to enable me to give my opinion in general, what plan it would be best to pursue.

It is true I found myself at first under some little restraint, from that freedom I would ever wish to exert; by discovering in the course of this day's conversation, a strong propensity in this gentleman for pursuing the former design; I mean that of Mr. RUDYERD: but when what has been already said upon that structure is considered, I must own that Mr. WESTON's attachment was very reasonably founded. There were other circumstances too, which might have been a still greater clog and impediment to the scope of my thoughts, had the gentlemen Proprietors suffered themselves to have been biassed thereby; I mean a partial View to their own immediate Interest. But I was soon released from every supposition of this kind; for on putting the query, that if any improvement could be made in the stability or durability of the structure, whether the Proprietors would wish to adopt it; though it should incur a greater expence than a mere re-erection of the last building? He replied, with an emphasis which gave me no doubt of his sincerity; that if there was a possibility of rebuilding the Lighthouse in any better or more durable manner than it had been, though almost half of the original lease from the Corporation of TRINITY HOUSE was then expired, yet the matter being now in their hands, they should think themselves bound, for the sake of posterity, to do every thing that lay in their power to render the new building not only effectual for their own time, but as permanent as possible.—And, on coming away, Mr. WESTON said, I was not to think myself at all indebted to him, or any of the Proprietors for the undertaking I was likely to be engaged in; since if either he or they could have heard of any person more capable of designing and executing such a work, he should not have seen me at his house that day: which valediction, though in the gross sense, it might be said to contain little of Obligation; yet as it at once shewed me that I was likely to be received with that degree of trust and confidence which is so essential to the success of an arduous undertaking; it thereby became a pleasing earnest of that disposition in the Proprietors, which must ever be satisfactory to an artist; that of wishing to have his work, whatever it might be, performed in the best manner; and therefore could not in this sense, fail to be more highly agreeable than any other kind of compliment.

78. THE models and drawings having been sent to me, I endeavoured by a full consideration of them, to investigate the particular plan of the respective architects; but could not trace



out that of either of them to my perfect satisfaction. They afforded me just so much light as to enable me to discern the want of more information: and I found upon further enquiry, that neither the models, drawings or prints were coeval with the structures they were intended to represent, except the print of Mr. WINSTANLEY's Lighthouse published by himself in the year 1699, before referred to; for as to the models, &c. relative to Mr. RUDYERD's, save a few original drawings, that shewed how some of the courses of stone were laid, as I have already mentioned, they were all of a late date, chiefly since the year 1734; and rather useful for repairing than rebuilding the house; exhibiting no more of the inside work, than what was discovered by the openings that were made at the time such repairs were carried on; so that at best those could afford but very defective information, as to the particular original design; though they had been necessary for conducting the repairs of that building.

From similar observations, the models had also been framed; but to render these more complete, to appearance, imagination was taken in to supply what never could have been obtained by real inspection: for, as no models, draughts or sections, that had been made at the time the house was built (except as before mentioned) were handed down to posterity; conclusions were drawn, from the things that were apparent, with respect to the inward structure; so that when any part of the case, or outside timbers that covered them, were taken off to be repaired, the models and drawings that were in consequence made by such kind of piecemeal discoveries, were in reality the best evidences I have seen of the nature of the structure, and therefore could not give me a full information.

This being the case, after all I could glean from the drawings and models, as well as every insight into the nature of the work, that Mr. WESTON from several interviews could give me; I was naturally led to consider what could be done by an erection entirely of Stone; as along with greater natural permanency of materials than wood, it would not be liable to destruction by fire; against which no absolute defence (as it appeared to me) could be applied, if rebuilt with timber. In fact, on first hearing of the late Lighthouse having been destroyed, I had conceived that the interior part of the foundation, and indeed for a considerable height, must have been a solid body of stone, though the outside might have been covered with wood, (as it appeared from the only figure of it I had ever seen); and which I supposed might have been thought necessary by the builder, to prevent that wash of the joints, that a very exposed situation might subject it to, in case the cement was not of the very best kind possible for water-works: and such having been my thoughts, my imagination was in consequence carried to suppose how such a building might have been put together in the most effectual manner. Coming therefore to town with these ideas, and finding how very short the best account of the real structure fell of answering my conceptions; I was encouraged, from the declaration of the only Proprietor I had seen, as being the sense of the rest, as well as from the apparent utility to the public, and possibly in the end to the Proprietors themselves, to turn my thoughts towards the practicability of a stone building: which proposition appearing in a light more favourable, in proportion as I thought more upon it; in a very few days I became so satisfied, that I desired an interview with the body of Proprietors upon a primary and leading Question.

79. AT this meeting I stated the great advantages that would arise from a Stone Building, which indeed were quite obvious to all; but the difficulty was, how such a building could be carried into execution; for though the Proprietors unanimously declared, that they would make no objection to any reasonable expence in procuring that durability and safety, which would be the evident result, if a building with stone could be effectually established; yet they very properly observed, that as the late building had fully answered the end, for almost half a Century; were any thing to fail, in case they altered the mode of the structure, for any Reason whatever, however laudable, they should be condemned by the public, for having attempted an alteration, though even for the service of the public; and the loss must fall upon themselves as individuals, if, on any account whatever, they should not succeed.—They likewise observed, that it had been generally thought by the best judges, that the safety and continuance of the late building, had in a great measure depended on the elasticity of the materials of which it was chiefly composed;

which enabled it to give way to the violent shocks of the sea, to which it was exposed: and that it was said, by those best acquainted with it, that its motion in violent storms was so great, that frequently the Trenchers were thereby thrown from the shelves in the upper rooms: and that most undoubtedly, in these great agitations, something must give way, which a stone building could not be expected to do, unless in the case of a total overthrow.

In answer to this I observed, that the great agitation which the late building was subject to, arose from its want of Weight, as well as want of Strength; that what I proposed would be both much heavier and much stronger; and therefore if the building would not give way to the Sea, the Sea must give way to the building. I further observed, that I had not met them at so early a time to debate the mode of construction of a stone building, or its properties; but to ask them a simple question: and that was, if I could convince their own understandings, that a building could be made with stone, not only so as to be more durable, but even more safe from every accident that could be foreseen, and not likely to be attended with a charge enormously more large, whether they would prefer such a Building to the last, which they had experienced could be consumed by fire? because, if not, it was to no purpose to spend time in ascertaining the mode of doing a thing that must ultimately be rejected; but rather apply that time as early as possible, towards investigating the best method of composing a structure upon similar principles with the former: I say similar Principles, because, as already shewn, there did not at that time appear to exist, any precise design of the former building: but that, if under the proviso mentioned, they would prefer a stone building; the *onus probandi* should be upon me; and if upon trial I could not satisfy their minds, as well as my own, of the practicability of my proposition, I would then quietly give it up, and as strenuously apply myself to what should upon the whole appear the most eligible: and as it would not take up much time to produce something in a rough way; as I understood it was too early in the season for any operations upon the place, no very material time could be lost. On this they unanimously agreed, that I should make the attempt to convince them, and if convinced, they would act accordingly; unless controuled by some superiour power.

80. IN reflecting upon the late structure, with a wish to retain as much of it as possible, consistent with the different nature of the material I had then in view, it appeared that the general form and size of the building, and distribution of the rooms of the house, were very proper and judicious. It appeared also most evidently, that had it not been for the moorstone courses, inlaid into the frame of the building, and acting therein like the ballast of a ship, it had long ago been overset, notwithstanding all the branches and iron-work contrived to retain it: and that in reality the violent agitation, rocking or vibration which the late building was described to be subject to, must have been owing to the narrowness of the base on which it rested; and which, the quantity of vibration it had been constantly subject to, had rendered, in regard to its seat, in some degree rounding, like the Rockers of a cradle. It seemed therefore a primary point of improvement, to procure, if possible, an enlargement of the base, which from the models before me appeared to be practicable. It also seemed equally desirable, not to increase the size of the present building in its Waist; by which I mean that part of the building between the top of the rock, and the top of the solid; and the Plate No. 6. (which has already been fully described) being supposed in my Reader's view, I must imagine him quite as well informed as I could be, at the time I am now describing. If therefore I still kept strictly to the conical form, a necessary consequence would be, that the diameter of every part being proportionably increased by an enlargement of the base, the action of the sea upon the building would be greater in the same proportion; but as the strength increases in proportion to the increased weight of the materials, the total absolute strength to resist that action of the sea, would be greater by a proportional enlargement of every part, but would require a greater quantity of materials: on the other hand, if we could enlarge the base, and at the same time rather diminish than increase the size of the waist and upper works; as great a strength and stiffness would arise from a larger base, accompanied with a less resistance to the acting power, though consisting of a less Quantity of Materials, as if a similar conical figure had been preserved.

81. ON this occasion, the natural figure of the waist or bole of a large spreading Oak, presented itself to my imagination. Let us for a moment consider this tree: suppose at twelve or fifteen feet above its base, it branches out in every direction, and forms a large bushy top, as we often observe. This top, when full of leaves, is subject to a very great impulse from the agitation of violent winds; yet partly by its elasticity, and partly by the natural strength arising from its figure, it resists them all, even for ages, till the gradual decay of the material diminishes the coherence of the parts, and they suffer piecemeal by the violence; but it is very rare that we hear of such a tree being torn up by the roots. Let us now consider its particular figure.—Connected with its roots, which lie hid below ground, it rises from the surface thereof with a large swelling base, which at the height of one diameter is generally reduced by an elegant curve, concave to the eye, to a diameter less by at least one-third, and sometimes to half of its original base. From thence its taper diminishing more slow, its sides by degrees come into a perpendicular, and for some height form a cylinder. After that a preparation of more circumference becomes necessary, for the strong insertion and establishment of the principal boughs, which produces a swelling of its diameter.—Now we can hardly doubt but that every section of the tree is nearly of an equal strength in proportion to what it has to resist: and were we to lop off its principal boughs, and expose it in that state to a rapid current of water, we should find it as much capable of resisting the action of the heavier fluid, when divested of the greatest part of its clothing, as it was that of the lighter when all its spreading ornaments were exposed to the fury of the wind: and hence we may derive an idea of what the proper shape of a column of the greatest Stability ought to be, to resist the action of external violence, when the Quantity of Matter is given whereof it is to be composed.

In Plate No. 13. Fig. 1. is a sketch representing the idea I formed of this subject. It is farther observable, in the insertions of the boughs of trees into the bole, or of the branches into the boughs, (which is generally at an oblique angle) that those insertions are made by a swelling curve, of the same nature as that wherewith the tree rises out of the ground; and that the greatest Rake or Sweep of this curve, is that which fills up the obtuse angle; while the acute angle is filled up with a much quicker curve, or sweep of a less Radius: and Fig. 2. of the same plate represents my conception of this matter.—In this view of the subject, I immediately rough-turned a piece of wood, with a small degree of tapering above; and leaving matter enough below, I fitted it to the oblique surface of a block of wood, somewhat resembling the sloping surface of the Edystone Rock; and soon found, that by reconciling Curves, I could adapt every part of the base upon the rock to the regularly turned tapering body, and so as to make a figure not ungraceful; and at the same time carrying the idea of great firmness and solidity.

82. THE next thing was to consider how the blocks of stone could be bonded to the rock, and to one another, in so firm a manner, as that, not only the whole together, but every individual piece, when connected with what preceded, should be proof against the greatest violence of the sea: for, I plainly saw, from the relations I had got, that as every part of the work, even in the most favourable seasons, was liable to be attacked by violent storms; if any thing was left to the mercy of the sea and good fortune, the building of the Edystone Lighthouse with stone would be tantamount to the rolling of the stone of SISYPHUS.

On this head I considered the nature of Cramping; which, as generally performed, amounts to no more than a Bond upon the upper surface of a course of stone, without having any direct power to hold a stone down, in case of its being lifted upward by an action greater than its own weight; as might be expected frequently to happen at the Edystone, whenever the mortar of the ground bed it was set upon was washed out of the joint, when attacked by the sea before it had time to harden; and though upright cramps to confine the stones down to the course below, might in some degree answer this end; yet as this must be done to each individual stone, the quantity of iron, and the great trouble and loss of time that would necessarily attend this method, would in reality render it impracticable; for it appeared, that Mr. WINSTANLEY had found the fixing 12 great irons, and Mr. RUDYERD 35, attended with such a consumption of time (which arose in great measure from the difficulty of getting and keeping the holes dry, so as to admit of



the pouring in of melted lead) that any method which required still much more, in putting the work together upon the rock, would in consequence inevitably, and to a very great degree, procrastinate the completion of the building. It therefore seemed of the utmost consequence to avoid this, even by any quantity of time and moderate expence, that might be necessary for its performance on shore; provided it prevented hindrance of business upon the rock: because of time upon the rock, there was likely to be a great scarcity; but on the shore a very sufficient plenty.

This made me turn my thoughts to what could be done in the way of dove-tailing.—In speaking however of this as a term of art, I must observe that it had been principally applied to works of Carpentry: its application in the masonry way had been but very slight and sparing; for in regard to the small pieces of stone that had been let in with a double dovetail, across the joint of larger pieces, and generally to save iron, it was a kind of work even more objectionable than cramping; for though it would not require melted lead, yet being only a superficial bond, and consisting of far more brittle materials than iron, it was not likely to answer our end at all.—Somewhat more to my purpose I had occasionally observed in many places in the Streets of London, that in fixing the Kirbs of the walking paths, the long pieces or Stretchers were retained between two Headers or bond pieces; whose heads being cut dovetail-wise, adapted themselves to and confined in the stretchers: which expedient, though chiefly intended to save iron and lead, nevertheless appeared to me capable of more firmness than any superficial fastening could be; as the tyé was as good at the bottom as at the top, which was the very thing I wanted; and therefore if the tail of the header was made to have an adequate bond with the interior parts, the work would in itself be perfect.

What I mean will be rendered obvious by the inspection of Fig. 3. in Plate No. 13.—Something of this kind I also remembered to have seen in BELIDOR's description of the stone floor of the great sluice at Cherbourg, where the tails of the upright headers are cut into dovetails, for their insertion into the mass of rough masonry below, and Fig. 4. of the same Plate is taken from BELIDOR's Plate\*.

From these beginnings I was readily led to think, that if the blocks themselves were, both inside and out, all formed into large dovetails, they might be managed so as mutually to lock one another together; being primarily engrafted into the rock: and in the round and entire courses, above the top of the rock, they might all proceed from and be locked to one large center-stone.—After some trials in the rough, I produced a complete design, of which Fig. 5. Plate 13. is the exact copy; the dotted lines representing the course next above or below, which in the original was drawn from the same center, on the other side of the paper; so that looking on each side separately, each course was seen distinctly; or looking through the paper, the Relation of the two courses, shewing how they mutually broke joint upon one another, was clearly pointed out: and this method of representation was pursued throughout; but not being practicable in copper-plate work, I am under the necessity of introducing the method by dotted lines, though attended with some degree of confusion of the main design.

83. IN like manner, upon the ideas assumed, concerning the particular figure of the outside of the building, with the draughts and models of Mr. RUDYERD's Lighthouse before me; it was not long before I made out a fair section of a stone building, such as to me appeared practicable on the principles before mentioned. Figure 6. in the same Plate, is a reduction of it to half the size of the original; which, with the copy of the first fair plan, shewing how all the stones composing the same course were to be mutually locked together, by a new method of dovetailing, I am the more inclined to insert, as a part of this work; because I esteem these Prototypes more perfect in themselves, as a general scheme, than what was on further consideration actually adopted and executed; because many things were obliged to be varied, in order to render the whole more suitable to the situation, which would not have been varied had it not been on account of particular considerations: and those variations, together with the reasons for the same, will be pointed out in the detail of the parts, in the progress of the work.

\* Architecture Hydraulique, Part II. Tom. I. Plate 36. Fig. 4. Page 272.

It is obvious that in this method of dovetailing, while the slope of the rock was making good; by cutting the steps (formed by Mr. RUDYERD) also into dovetails, it might be said, that the foundation stones of every course were engrafted into, or rather rooted in the rock; which would not only keep all the stones in one course together; but prevent the courses themselves (as one stone) from moving or sliding upon each other.—But after losing hold of the rock, by getting above it; then, though every stone in the same course would be bonded in the strongest manner with every other, and might be considered as consisting of a single stone, which would weigh a considerable number of tons, and would be further retained to the floor below by the cement, so that when completed, the sea would have no action upon it but edgeways; yet as a force, if sufficiently great might move it, notwithstanding its weight, and the small hold of the sea upon it; and break the cement before time had given it that hardness which it might be expected to acquire afterwards; I had formed more expedients than one, for fixing the courses to one another, so as absolutely to prevent their shifting; but deferred the choice of these expedients till a stone building had been approved and resolved upon.—I also foresaw that though the cement in the bed of each course, while remaining entire, by excluding the water, would in reality take away the whole tendency of the sea to lift it; yet while a course was unfinished, and the mortar not sufficiently set or hardened, the violent action of the sea upon the cement in that state, might entirely wash it out; and then the sea would act in the same manner in lifting, as if there had never been any cement put in: I therefore formed a variety of temporary expedients to prevent this, while the course was unfinished; for after a course was once finished and the cement was hardened, there could be no danger of such a thing happening: but I shall not trouble my reader with a recital of those expedients at present, as they will more properly come in along with the reasons of my choice, in the detail of the actual proceedings.

84. WHILE I was digesting and settling my mind upon these matters, I had frequent conferences with Mr. WESTON, who had actually, two or three times, been upon the rock; and as from him I learnt that if I was then at Plymouth, a probability of landing upon the rock so early in the season was not to be expected; I took so much time as maturely to arrange my thoughts, previously to a full explanation of my general scheme, and yet to leave time for the necessary preparatory steps, in case what I had then in contemplation should not be approved of.—I therefore, as early as was consistent with these circumstances, desired another interview with the body of Proprietors; when by the help of the two drawings above referred to in Plate No. 13. Fig. 5. and 6. I fully explained my design above stated; with which after mature consideration, they declared their perfect satisfaction: and that the scheme, was not only in itself practicable; but, as appeared to them, the only means of doing the business effectually for the general good of the public.—They however observed, that though they themselves were unanimous in this opinion; and though the condition of their receiving the light duties\* was that of maintaining a light upon the Edystone Rock; and that though neither the form, nor materials of the building for that purpose were prescribed to them; yet they thought it right, not to rest the determination of these matters with themselves only, but to have the concurrence of the Board of ADMIRALTY, and of other superior opinions; which being taken, it seemed to them (on supposition of their approbation) that I should not then have any thing to do, but to go down to Plymouth and prepare for the execution.

To this I observed, that we were not yet ripe for taking those opinions; for at present the scheme was so much in Embryo, that it existed merely as a work of imagination, formed from the representations and informations, I had then received: but that when I came to see the Edystone Rock, with my own eyes, and observed its nature and situation; it was a possible case, that I might myself be of a different opinion; and ultimately recommend a structure as near alike, as we could tell how to make it, to the last.—That the necessary steps seemed to be, that since the new scheme, had in its outlines been honoured with their approbation; it was now, or,

\* *Viz.* One Penny per ton upon all British ships, outward or homeward-bound, that pass the Edystone; on, or from foreign voyages. One shilling per vessel on coasters; and double these duties on foreign ships when they come into British ports. The King's ships being all free.

as soon as the season should become likely to obtain a landing, would be proper for me to go to Plymouth, and make my own observations; and take such exact dimensions of the rock itself, as would be necessary to enable me to erect a structure upon it of either kind: as also to examine into the nature and distance of such materials, as should appear to be necessary; by which means, on my return, I should not only be able to advise as to the sort of building; but to make an exact model of the rock, and of the fabric I should ultimately propose upon it; all which, if approved by the Proprietors themselves, it would be then time to submit it to the opinion of the superior Boards: for, we should cut but a small figure indeed, if after having received their approbation, we should find ourselves under the necessity of telling them, that what we had proposed was premature, and would not do; and that we were obliged to recur to the former construction.

This proposition being approved of by the Proprietors, it was determined that the Lighthouse should have the same general Form and Convenience, as the last; but as to the matter, whether of wood or of stone, or what kind of stone, should be referred to my further enquiry and report.

It being yet rather too early in the season, for my journey to Plymouth to be of any probable use, I employed the residue of my time in preparing such instruments and necessary matters in London, as I foresaw might be useful; however, to lose no material time, it was concluded I should set out for Plymouth on the 22d of March 1756, where I arrived on the 27th.

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## CHAP. II.

### CONTAINING AN ACCOUNT OF THE PROCEEDINGS AND OCCURRENCES ON MR. SMEATON'S FIRST JOURNEY TO PLYMOUTH IN THE SPRING OF THE YEAR 1756.

85. **I**N my journey to Plymouth, I had nothing to regret but the loss of time that I suffered, which was occasioned chiefly by the badness of the roads.—Notice having been given of my coming, I had an early visit from the persons who expected me; and in particular from Mr. JOSIAS JESSOR, with whose general character, as given to me, I have already made my reader acquainted. To him I was principally referred for what information and assistance I might stand in need of; and had the satisfaction to find him perfectly to answer the character that had been given me of him; who besides being an approved workman in his branch as a shipwright, I found a competent draughtsman and an excellent modeller, in which last he was accurate to a great degree; he therefore appeared to be a very fit person to overlook the exact execution of a design given.

To him I soon hinted the probability of building the house with stone, at which he seemed much surprized, and asked me how I meant to fasten the outside Timbers: I told him, that if it was built with stone, I meant to use no timber at all about it; at which he was astonished, and said, it would be impracticable in that situation; or if it could be done, it would not stand: but on endeavouring to come at his reasons for thinking so, I found it was no other than the idea of security, which had been generally conceived to have arisen, from the rocking of the late wooden house.—After shewing him the sketches of my design, and explaining the same to him, as I had done to the Proprietors, he seemed to be tolerably satisfied; and said, that as I proposed to do without cramps or iron, in binding the lower part of the works together, it would certainly be a great saving, both of expence, and, what in this case was more valuable, of Time.

He also observed to me, that the worms had brought on so general a decay in the foundation part of the late Lighthouse, not only of the outside timbers, which could easily be shifted\*, but also of the interior ground timbers, that several of them had in his time been obliged to be shifted; and that this generally proved an operation, not only tedious and difficult, but even in itself imperfect; as the new timbers put in, could scarcely be brought to an equal bearing with the others: and that in consequence (the greatest number shifted having been on the S. W. quarter) the whole

\* The term shifting a timber in Shipwrightry signifies in general the substitution of a piece of new timber in the place of a piece of old.



building had got a considerable List or leaning to the S. W. where the rock was lowest; and that from this cause of decay, as well as the necessity of repairs, every year growing more and more pressing, it must have become in a course of years, not only exceeding difficult, but very expensive to have kept standing; even if any adequate remedy should have been found out against the worms attacking the new timbers, as many of the old ones were in a very decayed and porous state at the time of the destruction of the late building.

86. I WAS impatient to go off to the rock; but though the wind was fair at N.W. which was the favourable quarter; yet it had blown so hard, that Mr. JESSOP assured me we could not effect a landing upon it for a day or two longer at the soonest; I therefore turned my thoughts to other matters.—I waited upon FREDERICK ROGERS, Esq; Commissioner at Plymouth Dock, who with great civility and politeness assured me, that no assistance to my undertaking, which he could give, should be wanting. I also went to some of the artificers recommended by Mr. JESSOP to give directions for tools, to make trial of the manner, and with what expedition we might be able to work the rock; and also instruments and utensils to enable us to take a plan thereof.

87. THE 2d of April being the first day there was any probability of landing on the rock, we set sail; it being at that time near the height of the spring tides, the wind easterly and moderate. We got within a stone's cast of the rock, but could not attempt to land, as the sea broke upon the landing-place.—Though we could not land, yet as the tide was at its low ebb, I had a good view of the rock, and an early opportunity of correcting many errors that I had been led into by the incorrectness of the several models and draughts which had come to my hands; and indeed I never should have had an adequate idea of this very turbulent place without seeing it.

88. ON the 5th of April we made our second voyage, the wind at N. W. and very moderate, so that though we went out of Sutton Pool at Plymouth before the water began to ebb, yet we did not arrive at the Edystone till it was nearly low water; and then I was rejoiced with setting my foot, for the first time, upon the Edystone. We staid there  $2\frac{1}{2}$  hours; that is, till the sea began to break from the west side over the rock at the landing-place; which my experienced guides pointed out as the last warning for our departure. Having employed myself while upon the rock in taking a general View of the whole, I could not perceive any remains of the house, either upon it, or about it; except the greatest part of the iron branches which had been fixed by Mr. RUDYERD; and some of the moorstones, which might be discerned lying in the bottom of the Gut: we sounded 12 feet water then upon them, which compared with former observations of Mr. JESSOP, shows that the Gut was filled up full two feet perpendicular, by their having tumbled into it, and there meeting with a place of repose.

I then observed such traces of the situations of the irons fixed by Mr. WINSTANLEY, as that it would not be difficult to make out his plan and the position of the edifice; from whence it appeared very probable that Mr. WINSTANLEY's building was overset all together; and that it had torn up a portion of the rock itself along with it, as far as the irons had been fastened in it.

On this view I soon perceived that Mr. RUDYERD's iron Branches, as then called, were much smaller and shorter than he had described them to be at the bottom of his print; that many of them were loose, and some broken and bent: and I remarked that in regard to the steps, described to be cut upon the rock, there were only five of them, of which the traces were remaining: so that there was but one flat or tread of a step above the centre of the house; and the upper part of the surface of the rock above that, was a sloping plain as it had been at first. Three steps, of the five now remaining, seemed to have been but faintly cut, and the uppermost but one was so imperfect, that I supposed a large spawl or splinter had come from it; and this appeared the more probable, as the uppermost step was so shaken, that another large spawl might have been easily raised from it, by a slight action of a wedge. Above the uppermost step the rock seemed to be of a softer nature, was cracked in many places, and probably had received some damage from the fire. None of the steps appeared to have been cut with much regularity, either as to level or square; but to have all the marks of hurry upon them.—In the center of the house a slight footing was cut for the mast, suitable to a square of 18 inches, with large iron branches answerable

to two of its sides; and a small hole bored in the center of about 1½ inch diameter, being six inches deep. By consulting Plate No. 7, many of the above matters will be made apparent to the eye.

I then proceeded to try the degree in which the rock was workable, and found that from a flat surface indifferently taken, I could with a pick sink a hollow at the rate of five cubic inches per minute; and could cut or drill a hole with a jumper of 1¼ inch diameter, at the rate of one inch deep in five minutes. I also tried a method of forcing two holes into one by a square flat-faced bruiser, or Pummel; so that, if there should be occasion, I might be able to make a continued groove; or let in an iron branch, in the manner of Mr. RUDYERD, and I had the satisfaction to find that the whole succeeded to my wishes.

89. IN considering what had occurred, there was not any thing that put on the appearance of Impracticability in the fixing a stone building; but I was forcibly struck with the idea that nothing would more immediately tend to expedite our work, than the securing a more safe and certain landing; as by that means we might frequently be enabled to work upon the rock, when otherwise we could not land thereon, or get off again when landed. I therefore lost no time in turning my thoughts to this subject, as a matter of great importance: for as I saw it must frequently happen, when the vessels cannot get in, and must in such case lie off the rock, waiting for a favourable time to enter the Gut; that in the interim, tides might change, ground swells come on, winds shift, and storms arise, which would of course make it advisable to return to Plymouth, if possible, though the purpose of the voyage was unperformed: it seemed therefore of the greater consequence that no practicable opportunity should be lost, for want of proper expedients.

At this time my knowledge of these sources of uncertainty, in a great measure depended on the relation of others; but my own after-experience, in the course of the performance of this work, has most fully and amply verified them: and I may add, that when vessels had got with some facility into the Gut, they frequently could not get out again without extreme danger: for as the larger sort had not room to turn in it, they were in reality obliged to go out stern forward, in case they came in the right way: the Sugar-Loaf Rock (See Plate No. 3.) being so critically placed, and shallow water on both sides of it, that it prohibits a thorough passage. Indeed I was told, that by the skill and expertness of those seamen who had frequently attended the service of the Edystone, not only row-boats, but the attendant vessels, after having delivered their cargoes, had been carried quite through at the top of an high tide, with a fair wind and smooth water\*; but this neither is, nor ought to be, attempted in common.

The two voyages I had made, were in a small sailing vessel of about ten or twelve tons burthen, built on purpose for attending upon the late house by Mr. TOLCHER the agent, and was called the Edystone Boat.—By the experience of these two voyages, it occurred to me, that while the Lighthouse was standing, if the boat should have happened to be staved upon the rocks, while lying in the Gut, there was a possibility of the men being saved by getting into the house, as the lightkeepers would have been ready to throw out a rope and assist them: but if any accident of the kind was to happen now that the house was down, and no shelter or protection to be had, there was but a chance of their being saved; and these considerations being likely to cast a damp upon every exertion to land, I determined to go out no more without another sailing-boat to attend, and accordingly hired a fishing vessel of an equal size with the Edystone boat.

90. THE 9th of April the wind and weather having become favourable for another attempt, we set forward at midnight between the 9th and 10th, the wind being then at N. W. and so moderate, that to expedite our passage we used our oars: but by the time we got a-breast of the Ram Head, it had veered to S. W. and began to blow so hard, that in three hours, finding we had made little progress towards the Edystone, we returned and re-landed at Plymouth at six in the morning†.

\* The Sugar-Loaf is overflowed at half tide in still water.

† The mention of this voyage might very well have been spared; but the brief recital of it, and of such other fruitless attempts as occurred upon this visit to Plymouth, will serve as a sample, and (better than any form of general words) make my reader sensible of the great difficulty and uncertainty that naturally attends the landing upon the Edystone Rocks.

It was not till the 14th that we had any prospect of success at sea; the intervals between these attempts were therefore filled up in looking out a place proper for a work-yard; which to answer the purposes of a stone building, I considered should have the following properties: 1st, That it should be accessible not only to the boats or craft immediately employed in the service, but to such larger sloops and vessels as were to be employed in bringing stone from the respective quarries: for this purpose, it was necessary, that there should be a wharf or quay, or the capacity of erecting one; against which there might be nine feet, or at least eight feet depth of water at the high water of Neap tides. 2dly, That this should be in a harbour, interior to that of Plymouth Sound, where vessels might lie sheltered and in safety from all winds. 3dly, That it should be readily accessible to vessels coming in with their cargoes from the sea. 4thly, That the navigation outward for our own craft to the Edystone, should be attended with as little intricacy, difficulty and uncertainty, as possible; in short, that there should be no material obstruction to their getting out at high water into Plymouth Sound. 5th, and lastly, That there should be a level area to the amount of about 50 yards square, or a capacity of making such a one.

With this view I searched all the likely places I could hear of in and about Plymouth, to the amount of eight or ten in number; but found them all to be wanting in some of the requisites; or previously occupied in such a manner as to make it too expensive for us to acquire an establishment in them. It is unnecessary to mention the particulars and the reasons for rejection, except what relates to one of the situations, that had been the work-yard of my predecessor, and on that account may deserve a more particular notice.

This place, which is called Emparcombe, tradition has pointed out to be the spot where Mr. RUDYERD framed and fitted up his works ready for the sea. It is situated upon the east side of an interior bay that proceeds from the Hamoaze\* behind Mount Edgcombe†. The principal trace that remained of his works, was a row of cottage-houses, said to have been originally erected for the lodgment of himself and his workmen‡.—From the discretion that Mr. RUDYERD had shewn in his general proceedings, I could not doubt but that this place which he had pitched upon, must fully have answered his purpose: but as, in case of a stone building, the tonnage of the materials to carry off, was likely to be considerably more than double of Mr. RUDYERD'S, I found it very indifferently suited to mine; for it seemed wanting in every requisite except the second; and was peculiarly defective in the first: and I could scarcely imagine he had made choice of it for any other reason, than that of his workmen being retired from the bustle that attends the town of Plymouth in time of war, and that it did not in the least interfere with the King's works.

Indeed I found no procurable place, completely made to my hands; but that which seemed the most nearly to contain all the requisites, or the capacity of making them, was in a field adjacent to Mill Bay, about a mile west from Plymouth. This bay, and particularly the west side of it, was well screened from all winds, for all kind of vessels that we could want. Its entry was sufficiently wide, but yet not too much so; the water deep and the headlands bold: and though the mouth is well protected from the surge of the Sound, by the island of St. Nicholas, now more generally called *Drake's island*; yet the passage out to the Sound, as well as the coming in, is very easy and safe. The greatest objection was, a want of depth of water towards the west shore; especially where, in other respects, the ground lay the most commodious for a work-yard: but it appeared that this inconvenience (amounting to about three feet want of depth in the shallowest part) might be remedied by first clearing a passage through the mud, and then sinking the natural bottom, which appeared to be a strong hard clay, so as to form a channel of sufficient width for the passage of vessels: and thus the business as to the obtaining of a work-yard was brought to a point ready for application to the proprietor of the field. See Plates No. 2. and 17.

91. THE weather still continuing unfavourable, my next excursion was to visit the nearest place to Plymouth where Moorstone which in reality is the true Granite, was found and worked;

\* The Hamoaze is that part of the harbour opposite the King's Docks near Plymouth; being the broad outfall of the river Tamar into the Sound.

† See the Plan No. 2 of Plymouth Sound, and of the interjacent sea including the Edystone.

‡ In the year 1787 I found at this place more respectable buildings.



and that was about fifteen miles from Plymouth, up the river Tamar, near Calstock, to which place I understood that river was navigable. The moorstone is found upon Hingstone Downs; and here I was first shewn the method of working it: which was by splitting it with a great number of wedges applied to holes or notches, cut (or, as they term it, pooled) in the surface of the stone, at the distance of about four inches, more or less, according to the size and supposed strength of the stone. These pool-holes are sunk with the point of a pick, much in the way that is done for the splitting of hard quarry-stones in general.—Here I was informed, that the harder the quality of the moorstone, the more exactly in general it could be split to the size or scantling required; and on the contrary, that the more soft and capable of being worked with the pick or other tool, the less regularly it would split: so that to bring this kind of stone to a true square, would require in the whole, near the same quantity of labour, whether of the harder or the softer species.—The moorstone of this place seemed to be of the harder species; but of the quantity remaining, the stones were not of so large a size as I expected to have met with.

In enquiring as to the prices of the work, I foresaw it would be to no purpose to ask the expence of shaping stones to the particular figure I wanted; because the workmen being totally unused to any work of that sort, the question would only have puzzled them, and the answers of course would at best have been indistinct, if not tending to mislead: I therefore founded my enquiries upon the price at which they could produce Ashler\*, by the foot superficial, when brought to a true square; and what was their price per gallon in forming stone Troughs, some of which I found they were in the practice of making. By answers to the first, I was enabled to form a judgment, at what price they could work moorstone by the foot, to a perfect regularity, after it was split into the proper scantlings for that purpose; and from the price of working out the hollows of stone troughs, I could judge of the expence of hollowing out the work by downright dint of labour of the pick, where no advantage could be derived from the use of the wedge or the hammer.

The operation of splitting granite is very curious; for, the apparent texture being without any particular direction, the parts seeming to be irregularly and coarsely huddled together, somewhat resembling a Plum Pudding; one would not imagine, that any degree of regularity could take place in their division by splitting; but the case is so far otherwise, that gate-posts are afforded in the rough square, at a very moderate price; and I have in this country frequently seen posts of Granite twelve feet long, and not above eight inches square, used instead of wood, for the mere purpose of supporting a Hovel, no part of them being so much as an inch out of straight, or flat: but it is to be constantly observed, that the strength of the stone, on each side of the bisection, is so managed, as to be nearly equal, otherwise the split will constantly encroach upon the weaker side. Indeed without this remarkable property in granite of splitting regularly, it would have been of little use in human life: for it is of so hard a nature, that steel will not cut it; and yet hard steel will bruise it; so that the prominent parts being gradually crumbled away by repeated blows, its surface can be brought to a great degree of regularity: and as the splitting procures plain surfaces nearly regular, as already observed, the accidental prominences can be reduced to regularity by a moderate degree of labour.

92. ON the 14th of April we went out to sea between five and six in the morning, for the fourth time, the wind being then at East, and very moderate; but it had been at N. W. the preceding evening, which determined us to get every thing ready for the morning's tide. We had scarcely got out of the Sound before it became more fresh and veered to the S. E.; appearances were now against us, but I determined to run out to the Stone; for though it was not very likely we should effect a landing, yet as the wind was fair to run to the harbour of Fowey, or as it is commonly called Foy; a port about six leagues to the N. W. from the Edystone, and a place I wanted to visit on account of there being in that part of the county, a much more considerable quantity of moorstone, as well as hands employed in working it, than I had yet seen, we proceeded in our voyage. As we ran further out, the wind became more fresh, and when we got out to the length of the Edystone, it blew hard: there was no possibility of landing; but I caused our boat

\* A term used by masons for stones prepared in the square for building with regular courses.

to lie off and on, at the distance of about one hundred fathoms, to observe the action of the sea upon the rocks, when the wind blew from the S. E. quarter; which indeed was very violent, the seas being broken into a very large and heavy spray. On steering for Fowey we stood before the wind, and therefore though the gale increased, still our little boat and attendant behaved very well: we however had so much sea as to make a safe harbour very acceptable to us; and as Fowey was pointed out to me, as a place of refuge when the wind came round in such a manner as to prevent our return to Plymouth, it became expedient to examine its most material properties with attention.

The entrance of this harbour is rather narrow for large ships; but the headlands are very bold, and there is nothing to fear but what is in view. There is deep water both in the entrance and in the harbour itself, which is considerably enlarged in width after passing the headlands; in short, when you are in it, it is both safe and commodious.—As the depth of the water enables merchant ships of almost any size to go in or out, at any time of the tide, when the wind serves, this harbour becomes of consequence; being critically situated in the bottom of the extensive bay formed between the Ram-Head and Deadman's Point; and where many good ships, had mariners been sufficiently acquainted with it, might have found a safe retreat from bad weather and shipwreck; it is therefore to be lamented, that from erroneous accounts, formerly given in some of the pilot-books concerning this harbour, ships have not ventured to go into it, when they might very safely have done so, owing to the false idea entertained of it; which was that of its being a tide harbour, with a Bar at its mouth; than which nothing can be more contrary to the truth.

In fact, Fowey Harbour may be called the Key to the Edystone service: for as from the Edystone, Plymouth Sound and Foy Harbour lie nearly at a right angle; when it blows right a-head from Plymouth Sound, a vessel steering to Foy will have the wind upon her beam; and as this will be a wind from the land, there never can be any great sea from that quarter, at so moderate a distance from the shore; so that any good sea-boat, may make her course good to Fowey: and should the wind be due North, a vessel may yet run under shelter of the Deadman, and afterwards turn into Foy: but if the wind is to the Westward of the North, she may then run under protection of the high land at the Bolt point to the Eastward, and get into a small harbour called Yealm; though in the course of my experience, we seldom had occasion to use it: for it never happened when the wind was too far to the West to get into Fowey, but we could always fetch Plymouth Sound, by making a single Tack or two at the most.

93. NEXT morning the 15th, the wind blew hard at S. W. we therefore set out for Livery, about six miles from Foy; and here we found WALTER TRELEVEN and son, to whom I was directed as the principal people in this district for working of moorstone. WALTER aged 60 acquainted me, that he worked at the stone-work for the late Lighthouse under his elder brother PETER TRELEVEN, who had the contract under Mr. RUDYERD. He informed me, that none of the stones used therein were above a ton weight; that they were all cramped with iron, each to its neighbour; and the outside courses to those below; but so, that none of the cramps could be seen on the outside; that they were all finished at that place, being tried together upon a flooring of boards, and the cramps let in, and that the cramps were made from a pattern he had from Mr. RUDYERD.—PETER TRELEVEN, aged 80, was still alive, but so infirm and ill that he could not see us: I therefore desired his brother WALTER to ask him a few questions; and particularly whether there was any kind of mortar or cement used in the stone-work; it being Mr. JESSOP's notion, from what he had observed, that there was not, which PETER TRELEVEN confirmed: but it seems that neither he nor WALTER had ever the curiosity to go upon the Edystone Rock.

We then went to see the stone, and the way by which it was to be carried down to the water side to be shipped. The pieces of stone are here in general of much larger sizes than those we saw at Hingstone Downs, and are of a quality much more free to work, but will not split so true, as I had before been informed. I saw one stone apparently without crack or flaw, which curiosity prompted me to measure, and found it to contain not less than 400 tons\*. The distance of the

\* The moorstone or granite of this country that is wrought for sale, not only at this place, and at Hingstone, but every where that

place of working the moorstone to Parr, the place of shipping it, is about three miles, through very bad roads, and by means of carriages but indifferently contrived, which in this country they call Ploughs: they were not then in practice of drawing above a ton and a half at a time, and to move this, they were obliged to yoke a team, consisting of a great many bullocks and horses. I made similar enquiries here, to those I made at Hingstone, to ascertain the price of work, and found it upon the whole to amount nearly to the same as there. The stone here, though of a quality considerably softer, was yet very sufficiently hard for any purpose of building, and equally unperishable by the effects of weather, with the hardest: and as the quality of its being more easily to be worked with the pick, seemed better adapted to produce the dovetail shapes I had in view, at a moderate price, and as stones could be got here of any size that could be moved from the place, the stone of this district seemed upon the whole more likely to suit my proposed operations, than what I had before seen.

We were informed that a great part of the stone wherewith the walking paths of Westminster Bridge were laid, were gotten from this place. It distinguishes itself, by being of a much coarser grain, with long white spar-like pieces, frequently of two inches and upwards in length, and which from similarity they there call Dog's Teeth; whereas the moorstone of Hingstone, was of a smaller and closer grain, and much interspersed with the black Mica or Tale which is one of its component parts.—The morning of Saturday the 16th, the wind still continuing fresh at S. W. we this day took the opportunity of returning to Plymouth by sea from Fowey\*.

94. ON Sunday and Monday the 17th and 18th, it blew very hard at N. W. On Tuesday morning the 19th, the weather being very fine, clear and calm, we went out the fifth time for the Edystone; but the little breeze there was being right a-head, we tacked and rowed the whole day; and at night found ourselves about four miles from the rock. As the day was perfectly serene, we had the mortification of seeing every thing calm and quiet about the rock, without being able to get near it. Upon the turn of the tide in our disfavour, we dropt anchor, in hopes of completing our voyage the next day's tide; but in the night it began to rain and blow so hard from the S. E. that we were glad to weigh anchor and come home; and in returning, the wind veering to the N. E. and blowing very hard almost right a-head, we had a laborious work in turning to windward and regaining Plymouth.

The event of this last voyage pointed out to me very strongly, that the much greater tonnage of the stone, which must be necessary to be carried out and fixed, in case of a stone building, than was necessary in the compositions of my predecessors, would make the uncertainty and delay that they have described to be attendant upon their voyages, in order to fix their work, bear far heavier upon my scheme than upon theirs; and thereby occasion the whole time of the performance to be lengthened; a circumstance that would be very disagreeable to all concerned. It therefore appeared to me, that had a vessel been fixed within a quarter of a mile, or some such competent distance from the rocks, and which should be capable of lodging the workmen with all their tools, and loose materials; the several pieces of wrought stone only excepted; that then the workmen might by means of small row boats or Yawls have effected a landing both of themselves and their materials; and have been at work upon the rock the greatest part of that day; which we, as voyagers, lost the whole of in fruitless labours and endeavours, to get to the place of action. On consulting Mr. JESSOP upon this idea, he recommended that we should build a strong and very well found sloop of about 50 tons burthen, with iron chains for mooring her upon the rocky ground, which, as has already been observed, every where prevails in the vicinity of the rocks of the Edystone: and that her inward lining or ceiling, as it is termed, should be caulked equally well with the outside planking: so that the outside planking might then

I have had an opportunity of observing it, is not produced from quarries; but lies in pieces, generally roundish, upon the surface of the earth, somewhat sunk into the same; and this is used in preference, as being the most easy to come at: but the Miners find, that it lies underground in very thick and solid Strata, through which they are frequently obliged to sink Shafts or pits, for a great number of fathoms. It is called Moorstone from its being generally found upon the high grounds of this country, which are chiefly moors.

\* Doubtless it was this port that Mr. WINSTANLEY mentions, § 18, that he was frequently obliged to go to for shelter, and that it took him the greatest part of the next day to get back to Plymouth.



suffer great derangement, and even be in part destroyed by touching upon the rocks, while the inside remaining entire and water tight, would be sufficient for the buoyancy of the vessel; and if sloop-rigged, she would lie very snug and close while at her moorings; and in case of being accidentally broken loose by a heavy storm, she would be easily manageable and got under way, so as to be able to reach some port; either Plymouth, or to the East or West, and be easily replaced after the gale was over. To this scheme there appeared only one objection, and that was the difficulty there might be in clearing the water from between the Plankings; but that it seemed, might readily be obviated by making two pumps; one to act between the plankings, and the other within the vessel. But being apprized that a vessel was then fitting out in the river Thames, with chain moorings, not only to enable her to lie upon the rocky ground; but to continue there all winter, as a temporary floating Light; in some degree to supply the want of a Lighthouse; we concluded, that in case this vessel was ordered to be moored sufficiently near the rocks, to answer the double purpose of the Building and of the Light; that, provided there was sufficient room and accommodation, the expence of the Store-Vessel above proposed might be saved; and therefore it was proper to postpone our putting any thing in hand relative to this object, till the determination in respect to the floating light-vessel was known: and in case that did not turn out to our purpose, the other expedient might then be adopted.

95. DURING this interval on shore, I occupied myself in various miscellaneous matters, and in procuring the best information I could of such things as it appeared necessary to have some knowledge of before the principal work was set about. In particular, on repeating my visit to Commissioner ROGERS, he took an opportunity of shewing me a piece of Portland Stone, that had been cut out from a part of the King's Docks there, which had been wholly lined with that material.—This specimen had been drilled with a great number of holes, something similar to the perforations made by the worms of ships; and as this had doubtless wholly happened since the stones were placed there, it was a circumstance of a kind somewhat alarming. These holes I observed had been made by a small kind of shell-fish, something like a muscle, and that they were in general much smaller at the entry on the outside, than they were within; and apparently enlarging as the shell of the fish had grown in size. I was further informed, that these holes had appeared most numerous, or at least were of the most material ill consequence, near the draw-gates of the sluices, by which the water is drained off from the docks: for by this means, those sluices had become so leaky, that it became necessary from time to time to cut out several of the injured stones, and replace them with new ones.

Afterwards in looking among the marble rocks upon the shore of Mill Bay, near the place I had pitched upon as proper for our work-yard, I found several detached pieces of those rocks, that had in like manner been drilled through, resembling a honeycomb; and I likewise found some, near low water mark, where the solid rock had been entered in the same manner; from which I perceived, that the Portland stone had not suffered merely on account of its want of hardness; for the marble, which is much harder, seemed to be equally penetrable; nor had the pieces thus pierced suffered any decay in the nature of a rot; because the intermediate parts, between the holes, seemed to retain their original hardness: from these circumstances it appeared probable that every kind of calcareous stone might be subject to the like defect; and therefore that Portland stone ought not to be used for the outside of the Edystone Lighthouse, especially of the lower works: though it might be used with great advantage for the works within, on account of the greater ease with which it might be wrought.

I was not indeed led into this opinion, by any doubt I entertained that a house built entirely with this stone, would last much longer than a wooden fabric would have done; but in contemplating the use and benefit of such a structure as this, my ideas of what its duration and continued existence ought to be, were not confined within the boundary of an Age or two; but extended themselves to look towards a possible Perpetuity: and though it did not absolutely appear from what I had seen and heard, that a Portland stone building placed upon the Edystone rock, would in fact be penetrated by this kind of shell-fish; which seemed to be in a great measure confined to, and under low Water-mark; yet in cases where it is not necessary, it is certainly unadvisable to run

the least risque; for no one can say what the difference of situations may effect: and though the building, if attacked by any kind of known animal, might very reasonably be expected to endure much beyond the term which I understood the Proprietors had in their present grant; yet as I knew it to be agreeable to their wishes, I concluded that to give it all possible safety and probability of permanency, it would be advisable to make use of Moorstone for the foundation, if not for the whole of the outside work; it being of a quality not found either liable to be impaired by the above means, or subject to any kind of decay whatever by the injury of weather or time.

The owner of the fishing vessel that had hitherto attended us, being weary of the service, I hired a sloop of 25 tons burthen, with a commodious cabin, and decked over; but being too large to go into the Gut, it could only lie at anchor, and be used as an attendant Store Vessel.

96. THE 21st of April, the wind came about to the N. W. and was moderate; I therefore determined upon another attempt, and accordingly at twelve at night, went on board and proceeded on our Sixth voyage. We had a light breeze from the North, which carried us out leisurely to the Edystone, without the least difficulty, where we were so happy as to effect a landing between five and six, on the morning of the 22d; it was then nearly low water, and the tide at dead of the neap. The day being perfectly serene, we staid upon the rock till twelve at noon; which was till after high water: and though the sea at half a mile's distance appeared as smooth as the Thames in a calm day, yet a ground swell from the S. W. frequently run up very high upon the rock; and twice, a little after high water, ran over the highest point of it, though the dead level of the surface of the sea at high water, was full nine feet below the summit. My operations being now disturbed, we retreated to our vessels till two, when we again landed, and I went on with my business till nine in the evening, having worked an hour by candle-light.

The weather continuing fine, the Edystone boat lay in the Gut all night, a thing scarcely ever before attempted: the sloop to which Mr. JESSOP and I retired, lying at half a mile's distance to the North. At five next morning the 23d, I again landed and pursued my operations till eleven, when being a second time interrupted by the ground swell, we went to the sloop for refreshment, with an expectation of recommencing the work at two o'clock, as we had done the preceding day: but about one o'clock the wind began to freshen from the S. W. and at two it blew so hard, as to render our attempt to row the yawl into the Gut ineffectual. The wind still increasing, we lay at our anchors till five, in hopes of a change for the better; and then our situation became so uneasy that we made a signal for Plymouth, where we arrived at half past seven, which, though with the wind very fresh, and in our favour, was looked on as a quick passage.—In lying off the rock with the wind somewhat fresh at S. W. I observed on the retreat of the tide, that when the seas broke against the overhanging Breast of the rock on the West side, see Plate No. 9. the broken sea would fly 30 or 40 feet high; whereas a much greater ground swell at high water, meeting only with the regular slope, though it mounted much higher bodily, yet scarcely broke at all.

97. IN this place, I think my reader will expect some general idea of what had employed me upon the rock for three successive tides, amounting in the whole to full nineteen hours; and this was the taking such dimensions as would enable me to make an accurate model of such part of the surface of the rock as we were likely to have any concern with in the rebuilding: and which was principally effected by the application of an instrument that I had prepared on purpose; the idea whereon it was contrived I took from LEON BAPTISTA ALBERTI's treatise of Statues, added to EVELYN's translation of FREART's Parallel of Architecture. Wherein placing a kind of dial upon the head of the statue, with an index or ruler, turning about on the center of the dial, and from this ruler letting fall perpendicular lines, the several parts of the instrument will shew the situation, distance from the center, and depression of any given point of a statue below the plane of the dial, that the artist is desirous of ascertaining for his guidance; which instrument he calls a Definitor.

With this intent, I brought with me from London, the plate and index of a large Theodolite; being a foot in diameter, and sufficient to shew the single minutes of the degrees of the circle. This plate I screwed firmly down upon the surface of a steady wooden three-legged stool, which

when set level, would overtop every part of the rock.—Being set up, it was so adapted to the rock, that the center of the Theodolite was, as nearly as I could place it, perpendicularly over that hole in the rock, which I considered as having been the center of the late building; and the whole was adjusted to marks now fixed upon the rock, so that it could be taken down and set up, as often as we might have occasion; and so as precisely to answer the same position of parts.—To the index of the Theodolite was screwed a ruler, 16 feet in length, and divided into feet, inches and parts of inches, commencing from the center. This ruler was preserved from bending by its own weight, in any material degree, by a Rib raised upon its upper side; and it could be brought justly horizontal by means of a pocket Spirit-Level being placed upon it. The figure and manner of using it will be seen in the Elevation of the rock, shewn in Plate No. 7.—It is obvious that this index-ruler being carried horizontally round, along with the index of the Theodolite, would successively pass over every point of a circle of 32 feet in diameter: and that, a perpendicular being let fall from it, so as to answer to any point given upon the rock, within that area, the index would mark the degree and minute of the circle in which it is placed. The distance of that perpendicular from the center of the instrument would shew its distance from the assumed center of the former building; and the height of the perpendicular would shew the dip or depression of the given point below the plain of the instrument. The two former will be sufficient for laying down an exact Plan of the surface of the rock, as reduced to an horizontal plane; and this plan, being laid upon the plain surface of a proper block of wood or stone, and holes being drilled into the block from the respective points, at right angles to its plain surface, and to depths taken from the same scale as the plan was made by, will ascertain the respective points within the block, sufficiently for the forming a proper Model thereof.—The necessity of an exact performance of this part of the work, was proportional to the difficulty I had to get the proper measures taken; and indeed I was the more desirous that every thing relative hereto should be done with accuracy, as by that means many voyages and visitations would be saved, in adapting the work to the rock, in the course of our future proceedings.

As we were liable to be exposed to fresh gales of wind through every stage of our operation, there was no trusting to the perpendicularity of Threads and Plumbets: I therefore pursued the following method.—Having made indelible marks with the point of a jumper, upon the surface of the rock, at all notable places, I had a wooden measuring rod of about twelve feet long, and 1 1/2 inch square, divided into feet, inches and parts of inches, beginning from the bottom; this was shod with a rounded end or shoe of iron, which being set upon the mark to be ascertained, the rod was put into a perpendicular position, by means of a carpenter's square, having a spirit-level fixed upon one of its Limbs, the other limb being alternately applied to two sides of the rod, at right angles to each other. It was steadied in that position, by temporarily applying two slips of deal, as Shores to two of its sides that were at right angles; so that the lower end of the shores stepping against some hole or prominence of the rock, the bottom of the rod, together with the lower ends of the two shores, would form the base of an oblique triangular pyramid; while the part where the shores were held fast to the upright rod formed the Apex of the pyramid\*; this rod by this means was retained very stiff and steady in a perpendicular position.—The upright rod being thus fixed, the index-ruler was brought round, till it stopped against the upright rod, and then was shoved up, or let down by a shorter piece of a rod, slid against the upright one, till the index-ruler was brought to be truly horizontal, by means of the spirit-level being laid upon it: thus the upright rod would mark upon the index-ruler the distance from the center; and that ruler would mark upon the upright rod, the dip of the point on which it stood, below the level of the instrument; the brass index at the same time shewing the degree and minute.—In this way I took off 35 in number of the most remarkable points, within the limits above-mentioned; observing to have one at each end upon the plain flat part of each step, and so placed, that a line might be stretched between them from the point marked at one end, to that at the other end of the same step, without its being interrupted by the branches, or other impediments.

It might seem at first sight, that 35 points so determined, within a circle of 32 feet diameter, might be sufficient to lay down the included area, but in reality it was not so; for when I had taken three times as many more, I had not completed the observations and measures I wished:

\* The rods were here lashed together by a packthread.



the rock itself, as well as the work my predecessors had made thereon, being so very irregular.—These 35 primary points having been determined as above, the rest were obtained from them as follows. A primary point being fixed at each end of each step, between which a line could be stretched as before noted, the iron stanchions and particularities of each step were readily taken off upon their own level respectively, by means of parallels and perpendiculars: and by stretching a line between any other two of the primary points given, that were nearest and most advantageously situated, the situation of any other points wanted could be determined.—On my return to Plymouth, I made some progress in laying down to a scale, the measures taken upon paper. This enabled me to turn my thoughts towards a real design, which before had been only formed from imagination, assisted by such circumstances as I could lay together from former drawings, models and verbal relations.

98. THE 28th of April the weather turning out more promising than it had been since our last return, I determined to attempt a Seventh voyage; and accordingly went on board, and lay in Cawsand Bay that evening, to be ready for the first of the tide next morning. Our outset was favourable enough, but we had not got above a mile south of the Ram-Head before a fresh of wind from S. E. came on, and so suddenly, that our boat, which the seamen were heaving into the sloop, filled with water, and narrowly escaped being lost. We notwithstanding pursued our voyage towards the Edystone, but the sea breaking with violence upon the landing-place, we could not attempt to land. However having received information of another place, where moorstone was worked, which might be got to the waterside, not far from Falmouth, and the wind being now fair for that port, we bore away for it, and arrived there in the afternoon. The next morning, we went on horseback to Constantine, a place about four miles from Falmouth; where I applied to Mr. MATTHEW BOX, to whom I had been directed at Falmouth, as being the principal and almost the only man for moorstone in these parts.

The moorstone here, appeared to be of a quality, better both to cleave and work, than any I had before seen; for I observed by a piece of it, then under the hands of Mr. Box, that it might be cut and formed with a much superior degree of execution, than I had before conceived this sort of stone to be capable of.—He was at this time executing a Grave-stone, of the elevated kind, of which the pedestal of a column gives the idea; and in which he had formed the mouldings with so much delicacy and propriety, that I could not help considering Mr. Box as a capital artist in that kind of material; and therefore felt a secret joy in meeting with such a person.—Such however is the nature of man, that he may be great in one branch of his profession, and remain small in another: for on communicating the nature of my design to him, I quickly found, that he considered the forming and erecting of a well shaped Tomb-stone of Granite, as the greatest of all human performances; and that having lived and been brought up in a retired part of the country, from whence there never had been any considerable demand for moorstone, in point of quantity, he had chiefly applied himself to the finishing of smaller works for the gentlemen of the county within a moderate distance from him. He seemed therefore rather frightened than pleased, when after I had explained a little of the nature and form of the work I should be likely to need, I mentioned the extensive order that I might possibly give for this article; for, to the execution of it he formed numerous difficulties, and did not know what to ask, either for his stone, his work, or for the carriage down to Falmouth.

On considering the result of this interview with Mr. Box, and having now examined all the places I could hear of, where moorstone was worked, which lie tolerably convenient for water carriage to Plymouth; I became convinced of the necessity of making use of Portland, or some other free working stone for the inside work: for the granite, though preferable to all others in point of duration; yet being at best of a stubborn nature, and the working thereof confined to few hands, I perceived there would be no possibility of procuring so great a quantity in any reasonable time, at a moderate expence, as the whole house would take, especially if worked in such forms, and in so large pieces as would be required upon the principle of my first sketches.—The difficulties also that equally occurred to them all, as to the Land Carriage, seemed to induce the necessity, not only of confining the moorstone to the outside, but to take advantage of connecting those with larger and heavier stones within, that were more easy to procure, in order to reduce the size of the moorstone pieces, as much as would be consistent with the intended solidity of our

work; that is, to stones from half a ton to a ton and a half; but none to exceed two tons: and this appeared the more proper, as even to procure a sufficient supply of those, for the outside only, it might be necessary to give orders at all the places I had visited, at the same time.

The next morning, the 1st of May, being very moderate and the wind in our favour for returning, we weighed and went out to sea; but found a considerable swell from the S. E. raised by the wind of the two preceding days; and before we came near the Edystone (where I proposed to make a trial for landing if the weather should suit) the wind had come to the S. W. and blew fresh, which by opposing the S. E. swell, raised it still higher: wherefore we came that night into Cawsand Bay, and lay there to take the chance of the morning's tide; and be the more ready in case the weather should be then in our favour; but it proving otherwise, we returned to Plymouth, where we landed on Sunday morning the 2d of May.

99. WHILE I was prosecuting my work at home, of laying down the measures of the rock upon paper, I was somewhat alarmed with a report which prevailed concerning a number of French prizes that had been brought into the harbour, laden with fish; which having laid there some time, were decaying and putrefying\*. The report was, that by way of easily getting rid of them, it was intended to carry them out, and sink them near the Edystone: however this I could not regard otherwise than as a false rumour; supposing that an idea of disposing of them near that place, could never have been seriously adopted by any one in authority sufficient to give that order.—Early in the morning of the 4th of May, the weather appearing favourable, we made our Eighth attempt to go out to the Edystone; and as I was going aboard our sloop, advice was sent to Mr. JESSOP by Mr. JOSEPH TOLCHER of the Custom-house, that (being appointed to that service) he was going to see the covers of the Hatches of forty of the fish ships above referred to, nailed down; and that they were intended to be carried out and sunk at the Edystone. This in truth put me into a great consternation; but being unwilling to lose any opportunity of completing my measures upon the rock; and concluding that this purpose could not be so speedily executed as to prevent my having an opportunity of speaking with the officer deputed to carry them out, I determined to proceed in my voyage; but we had not got abreast of the Ram-Head, before a violent squall of wind and rain obliged us to return.—I immediately waited on Commissioner ROGERS to learn the truth of the above-mentioned report; who so far confirmed it, that he said they were to be sunk somewhere in the Neighbourhood of the Edystone: whereupon I told him, that it was sufficient to undertake to make a building that should be able to withstand the utmost violence of the sea: but it was too much to aid that powerful enemy with a thousand battering Rams, which these ships might be expected to prove, when broken to pieces by successive storms, and driven against the works of the building. Being asked how far from the Edystone it would be necessary to carry them; I told him it would not be safe at any moderate distance East or West, lest the flux and reflux of the tide should bring the wreck upon the rock; nor nearer than three leagues to the South. With this he promised to acquaint Admiral MOSTYN, who then commanded at Plymouth, and to return me an answer the next day: but as consequences of this kind seemed to have a tendency so dangerous and mischievous as to render the omission of any means I could take to prevent it, inexcusable; especially as they might be more easily foreseen than remedied, if the step was actually taken; I therefore wrote the same day to one of the Proprietors, who upon the receipt of my letter, applied to the Lords of the ADMIRALTY, to send orders for these ships to be sunk in some place at a greater distance from the rock than seemed intended: however, the day following I saw the Admiral, who politely assured me, that nothing should be done, that could any way obstruct the building of the Edystone Lighthouse, and that there was no such thing intended.

100. AS the weather continued unpromising till the 11th of May, I not only completed my rough plan of the rock as far as my measures had gone, but put together my thoughts, upon the subject of facilitating the landing, as also upon the proper mode of carrying on the works upon the rock with Expedition and at the least possible Expence, and communicated them by letter to the Proprietors.

\* It may be a necessary explanation at this time to say, that these were vessels that had been seized from the French before a formal declaration of war.

On discoursing again with Mr. JESSOP upon the subject of amending the landing at the Edystone, he informed me of an expedient they had sometimes made use of; which was, that when a vessel could not get into the Gut, so as to lie along-side the house when workmen were there for repairs, but yet could get so near, as to be out of danger, the weather admitting a barrel or log of wood with a rope fastened to it to be thrown from the rock; they took this up into the vessel or boat, and fastening timbers thereto they were successively hauled through the sea, and so got upon the rock. This had frequently been done, and though it did sometimes miscarry, and always took up time, yet it was the best method they had been able to devise; and the only one they had ever practised: but this expedient would little avail me, as a stone building appeared by every day's reflection, and the experience of every voyage, more and more feasible, as well as desirable; and as my proposed materials would not swim, a safe landing became a still more important object.

Mr. JESSOP was in truth the only person I had met with, who seemed to have a competent knowledge of the situation of the rocks; and though very careful and accurate in finishing what he undertook, yet he was not a man of much invention. He had however a very clear and sound judgment in whatever his practice and experience had put him into the way of knowing; and though apparent difficulties seemed to have kept his inventive faculties in awe; yet from his long experience, he generally proved an able adviser concerning the operations proposed to be performed at the Edystone.—As I looked upon a tolerably safe way to get to and from the building, and to lie there, particularly if it was to be of stone, as almost a *sine quâ non*; and had on this occasion fully communicated and explained my ideas to Mr. JESSOP and received his approbation, I took the first opportunity afterwards of acquainting the Proprietors therewith by letter, in nearly the following terms.

"I shall now describe the manner in which I propose not only to facilitate the landing upon the rock, but to increase the safety of vessels lying in the Gut.—The house-reef may in its natural position be considered as a pier, break-water, or bulwark to vessels lying there; and this would have been very complete, had it not been for the following circumstances. The rock that lies next to the northwards of that upon which the house is built, approaches nearly in height to that of its neighbour; and the top of it is about fifteen feet from the house rock\*; but between those two rocks is a low part, gully or hollow that is covered at about half tide, over which the sea breaks, even in fine weather, at low water, when there is any thing of a ground swell; and the waves cascade through this gap, into the Gut, as if, for the moment, an hundred mills were at work; which, when this takes place, not only endangers the filling of the boats, but raises such a surge in the Gut, as to cause the vessels to lie very unsteadily. This gap I propose to stop up, by first fixing an oak beam of at least twelve inches scantling upon a level from the house rock, to the top of the north rock, very firmly with iron bolts at each end; which beam is to serve as a Ridge-tree, somewhat in the manner of that for the roof of a house. Then to bolt firmly down upon the sloping surface of the rock below, two other timbers or sills, one on each side the ridge, in such manner, that three-inch planks being well spiked down upon the ridge-tree and upon the sills on each side, should form a figure like the roof of a house. The force of the sea therefore, whichever way it comes, will be broken by running up the sloping planking, and be prevented from running over in so large a quantity, whenever there is a probability of working upon the rock†.

"Moreover the east side of the house rock, though pretty nearly upright, is remarkably ragged and indented; and particularly upon its most projecting parts‡, some of which considerably overhang; if therefore there is not a constant care to keep a boat from touching when lying alongside the rock, her gunnel would be liable to be damaged by its asperities; and by its being hooked under the projections, she would be subject to be overset even in the finest weather: and

\* See Plate No. 14.

† This part of the proposition was never executed, principally for want of time at the proper season when it was possible to have done it; but being satisfied of the practicability as well as utility thereof as a temporary expedient, if done, I give it here a place as appurtenant to the subject.

‡ See the south views of the rock in Plates No. 6, 9, and 14.



this inconvenience and hazard, not only arises from the unsteadiness that is occasioned by the cascading of the water through the gully before mentioned; but when there is a breeze eastwardly, though not sufficient to occasion the sea to break upon the landing-place, or prevent working; yet by the boats being driven against the rock, they would be subject to the disasters above described; and what is more material than what I have already mentioned, if the workmen should be caught with a fresh of wind at East, the boats would be liable to be staved, whilst the men were getting themselves and tools on board."—I had already found by my own experience, that such kind of disasters we were subject to, and that we should be still much more liable to them in the course of the erection: and for an evil so great, the more simple the means, the better should the contrivance be esteemed by which it might be averted. To this end "I propose to fix timbers by bolts, upon the most prominent or projecting parts of the rock, in the manner of piles against the face of a quay, and at such distances as to be nearer together than the length of our boats; by which means their gunnels and sides being made to slide up and down against the piles, instead of the rock, there would be no danger of catching; and therefore a greater degree of security would take place, as well as that less care and attention would by that means become necessary\*."

101. WHATEVER advantages might ultimately result to the public, from having a durable stone building in lieu of a perishable wooden one, yet if the time that was necessary to be taken up in the erection, was likely to be greater than had been taken up by former builders, which was four summers, this would be a very sensible and striking objection to my proposition; and as the execution thereof would naturally require a greater time, in proportion to the whole additional tonnage of materials; this led me to every consideration that had a natural or artificial tendency to expedite the work.—I found that the customary payment of such artificers as had gone out upon the repairs of the late building, was five shillings per day, (or 35 shillings per week) from the time they held themselves ready to put their foot into the vessel to go out, to the time they were re-landed and discharged; without having any regard to the time employed in actual execution: what were the wages during the former buildings being in hand, I never could learn: but as there always had been, so long as memory reached, a house to receive and lodge the workmen, when they once got thither, the disappointments attending the difficulty of landing and fruitless voyages were, under that circumstance, of less consequence: I was therefore solicitous to form such a scheme for carrying on the works, as should make the service full as eligible to the workmen as formerly, at the same time that it should be their interest to exert themselves to the utmost; or at least to spend as much time upon the Rock as possible; and also, that they should be enabled to bear their labour chearfully during their continuance there, by not being subjected to any unreasonable degree of fatigue, by long periods of service. In consequence of all this, the work would of course be performed, not only as expeditiously as possible, but at an expence to the Proprietors, as low, in regard to the value of day labour, as could possibly be expected upon the former establishment.

It therefore seemed to me to be necessary, not only to moor a store-vessel in the neighbourhood of the rocks during the working season, but to employ two complete sets of hands for the outwork, to relieve each other in turns; so that whenever weather and tides would permit, the work might be pursued day and night.—That the workmen should on no occasion fall short of the common wages of the country for their support at sea, whether circumstances favoured or not; but that their making extra Wages should depend upon the time they actually spent upon the rock; where in general, a reasonable degree of employment could scarcely be avoided: and that it might be as much the interest of the seamen to use their best endeavours to get the workmen landed, and to encourage them to stay as long as they could, without imminent danger: their payment, as well as that of the foremen of each company, should all follow the same kind of proportion.—Upon these ideas I drew up and transmitted to the Proprietors, the following plan for carrying on the works; and which in effect, with very little variation, was afterwards carried into execution.

\* Those timbers or piles with Treenails through them, to answer the purpose of a ladder, are represented at P. Q. Plate No. 14.

## PLAN FOR CARRYING ON THE WORKS AND MANAGEMENT OF THE WORKMEN.

- 1st, That the Edystone service should by all reasonable inducements be rendered preferable to any other common employment.
  - 2d, That therefore (as a punishment) any one failing in his duty should be immediately discharged.
  - 3d, That the workmen should be divided into two companies; one company to be out at the Rock, the other to be employed in the work-yard on shore.
  - 4th, That every Saturday, the weather permitting, these two companies to change places; but the out-company not to return home till the in-company is carried out to relieve them.
  - 5th, Every man to have certain fixed wages weekly; and the same whether out or in.
  - 6th, Every man to receive — per hour over and above the fixed wages, for every hour he works upon the rock.
  - 7th, Every out-man to take all opportunities of landing upon the rock to work, when the weather serves, whether night or day, Sundays or work-days.
  - 8th, The in-company not to work either nights or on Sundays, except in case of necessity, and then
  - 9th, All extra work on shore to be paid for in proportion to double the fixed wages for the like time.
  - 10th, The seamen to be also at constant weekly wages, with an addition of a fee certain and proportionable every tide's work upon the rock.
  - 11th, Each company to have a foreman constantly with them while working upon the Rock; to be paid more than the common workmen, and in the same proportion.
  - 12th, The engineer and his deputy, to go off alternately week for week; and each week to go off as often, and stay as long as weather will permit, or the service require.
  - 13th, In case of sickness, or necessary absence of either the engineer or deputy, the whole (if possible) to be taken care of by the other.
  - 14th, All persons to victual themselves, but a bowl of punch to be allowed each company on their return on shore.
  - 15th, The foremen, workmen and seamen, to be paid every time the respective companies return on shore.
  - 16th, All work tools to be provided and repaired at the charge of the Proprietors, and to have a mark put upon each of them peculiar to the Edystone.
  - 17th, Every person hurt or maimed in the out-service to receive his common wages while under the surgeon's hands; and the Proprietors to pay the surgeon. This to be allowed on the certificate of the engineer, deputy and agent.
  - 18th, Any person desirous of quitting the service, to give a week's notice to the engineer or deputy.
  - 19th, The foreman on shore to take an account of every thing received into, or sent out of the work-yard; as also of the day's works of the company, &c. with him; under the check of the engineer or his deputy when on shore.
  - 20th, All smith's and plumber's work to be seen weighed by the foreman, engineer or deputy on shore; and all timber or wood work to be measured, and other materials taken account of by the same on receiving them.
  - 21st, The foreman afloat to take account of time and landings upon the rock, to be chequed by the engineer or his deputy when afloat.
  - 22d, An account of all matters done on shore to be given in weekly to the agent or accountant; and of all things done afloat by the proper foreman at the time of landing.
- The further consideration of these and many other matters, I referred to an interview with the Proprietors, to whom I was now in hopes of soon returning.

102. IN the afternoon of the 11th of May, we set out on our Ninth voyage, and got to the Rock in the evening; when we found the sea sufficiently quiet about it, to admit our landing;

but it being near dark, and blowing fresh at N. N. W. Mr. JESSOP and the seamen thought it not safe to go into the Gut that night, being of opinion that if the wind should a little increase, or get nearer to the North, we should not be able to get out again\*.

On this occasion the idea first occurred to me, that there might be a possibility of the water's being sufficiently quiet for the boat to lie alongside the rock (which used to be the criterion of the men being able to work thereon) and yet that the entrance or exit from the Gut might be impracticable or dangerous: this struck me with a most sensible chagrin, inasmuch that I scarcely slept that night; partly with mortification at our present disappointment, and partly in contriving means how to remedy so great an inconvenience: for the plan I had before laid down for the greater protection and security of the craft when lying in the Gut, would not have availed us in such winds and tides as were now our obstruction; and my scheme would still be imperfect, if after I had made the lying there less dangerous, I should not be able to reach it, or get out when there pressed with danger.

The blowing up of the Sugar-Loaf rock was undoubtedly the first thing that occurred; but this in fact would only be a partial remedy. To level the Sugar-Loaf to its base, would of itself be a serious work; as it never could be set upon except when the sea was remarkably still and quiet; and would of course take up that time which would be the most valuable towards getting the house-rock cut for the proper reception of a stone foundation; and of consequence prove a considerable hindrance to the execution of the main design: nor could this matter be expedited by an additional number of hands for that service; because as they could very rarely be applied, the incumbrance arising from a greater number of men afloat, than the main service naturally required, would prove a real obstruction to the general progress of the work: besides if the Sugar-Loaf was in fact levelled with its base, yet as the Gut would remain barred up within a small matter of low water, by flat rocks, which extend almost across it in that place; to get a clear passage to the South, with a sufficiency of water for the craft at low water, notwithstanding it presented itself as far from impossible, yet seemed likely to prove a greater work than that of the Lighthouse itself; and consequently not to be thought of at this time.

Having observed the use that was made of Transport Buoys, in the moving and mooring the king's ships in the Hamoaze; it struck me, that if a transport buoy of a size proportioned to our sort of craft and service, was moored with chains at the distance of about fifty fathoms directly North from the Gut, to which one end of a suitable cable or hawser should be bent (that is, fastened) and the other carried to the landing-place in the Gut; and to prevent its being fretted against the rocks, so much of it as would be liable to touch, to be a chain; this cable and chain being kept always in repair, during the working season, as there was nothing to hinder us from sailing to this buoy, when vessels could keep the sea, they might lie there till it was a proper time of tide to go into the Gut: and then by means of this communicating cable, we should be able to hawl them into and out of the Gut against wind and tide; and for facilitating of this with a few hands, I proposed a windlass of a new Contrivance† to be put on board each of our larger vessels that were to go into the Gut. Our buoy would also be attended with this further advantage, that in going out, the vessel having gained it, her sails might be set before she quitted it; by which means she would get under way, and shoot clear of the rocks, when the wind blew northerly.

In the morning I communicated this proposition to Mr. JESSOP, who thoroughly approved of it; and added, that if a couple of eye-bolts, at a competent distance North and South of each other, were fixed into the rocks on the East side of the Gut, to which ropes might be occasionally fastened, these would keep the boats from striking against the house-rock, when the wind was easterly; and such a contrivance would have been particularly useful the very last time we went out of the Gut.

103. THE 12th of May we landed on the rock at seven in the morning, and staid till eleven, the wind being at S. S. W. It having been moderate during the night, the boat lay very quiet;

\* It has already been explained, that there is no passage to the southward, through the Gut, on account of the Sugar-Loaf rock.

† This was by means of Wheel and Pinion, scarce heard of for such a purpose at that time.



but we at last found it advisable to quit it, but more on account of the rain than the wind, (though that was becoming more fresh) as we were wet quite through, and what was worse our papers were wet also: however having now taken all the most material measures, this circumstance reconciled me to every thing else.—At weighing to come home, our anchor having got foul of the rocks, we parted our cable, and afterwards in endeavouring to weigh the anchor by the buoy rope, we parted that also: so that we were obliged to leave the anchor behind us; the risque of which would have been prevented, had we now had a transport buoy, such as that proposed.

104. AS it was my wish entirely to complete my measures, if a favourable opportunity happened, without further loss of time; while I was preparing for my departure on the morning of the 15th of May, the weather again appeared favourable, and we proceeded on our Tenth voyage. We landed on the rock at half past eleven in the morning, and staid there till half past two in the afternoon. The wind being then Easterly and beginning to blow a little fresh, we found it proper to quit the place for fear of staving our vessel against the house rock, of which there would have been much less danger, as she would have been far more manageable, had the proposed fender piles, or Mr. JESSOP's proposition, been in use: for though we were six hands in the Edystone boat, and used our utmost endeavours to prevent it; in coming out of the Gut the boat struck against the north rock, and sprung a leak, though no considerable damage was done to her. Having now completed all the observations I was desirous of making, which I was the better enabled to do, as it was a low spring ebb, I took my leave of the rock for the present with great satisfaction, and arrived at Plymouth that afternoon.

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### CHAP. III.

#### CONTAINING TRANSACTIONS AND OCCURRENCES DURING MY RETURN FROM PLYMOUTH TO LONDON IN MAY 1756.

105. **I**N my return to London, I thought it necessary to take a view of the several places that had been pointed out to me, from whence freestone could be shipped for Plymouth; not so much indeed to acquaint myself with the nature of the stone itself, of which I had seen samples before; as to learn whether I could have the quantities worked upon the spot of such weight, dimensions and forms as I concluded would be needful; and to inform myself of the charge of freightage, and other particulars that I knew would be necessary to enable me to make any kind of estimate of the cost of the building; which I must expect would be required from me by the Proprietors; or at least that I should give them all the information that I possibly could, touching such things as related to the proposed work.

106. **W**ITH this view I first visited the quarries at Beare, near the S. E. corner of Devonshire, and near the sea-coast. I found the bed or Stratum of freestone worked here, was of a considerable thickness; and with so great a cover of earth upon it, that it was worked in underground cavities; the superincumbent Strata of earth, &c. being supported by pillars formed by detached parts of the Stratum left standing. Here the stone, which is of the calcareous kind, and in point of hardness and texture much like the Bath stone, but whiter, lies in so solid and thick a bed, that blocks might be cut out from it of any size required: and though the Stratum is very compact (that is, free from fissures) yet it is of so soft and workable a nature, that I found the workmen sawing out blocks from the general mass (or posts) with carpenter's saws, which they could do to any dimensions required; and though this stone was capable of being thus wrought, and was so free to the tool, yet I found that it hardened considerably after being exposed to the

weather, as was manifest by the buildings that had been erected many years at the village of Beare: the stone in the old buildings being in general covered with a kind of mossy coating; and workmen, with reason, look upon the stone so coated, as not to be in a state of waste or decay. However, though hardened by time and weather, it yet seemed of a softer nature than I would wish for the construction of a building, that in every step of its erection would be subject to the extreme violence of the sea.

107. MY next visit was to the Isle of Portland, at which place I had an address to Mr. ROPER; who was the principal agent, or manager at the quarries for — TUCKER, Esq; of Weymouth, the principal quarry-proprietor or worker there.—I found Mr. ROPER a very plain, sensible, intelligent person; and as this isle, as it is generally called, seemed to contain many things that awakened my curiosity, I was very glad to accept of him for my conductor or guide; and as being one of the principal residents upon the isle, and particularly versed in the works peculiar to it, no person could better have fulfilled my wishes.—Upon the commencement of the works of Westminster Bridge, some time about the year 1739, Mr. ROPER was sent down by the contracting mason, as foreman, with a gang of masons or stone-cutters from London; who were, according to moulds and drawings, to hew the stones upon the place, to save the freightage of the waste: for, it is to be observed, that previous to this period, the stone sent from Portland had always been shipped off in the rough, or rather what is called rough scappelled blocks; to be sawn and fair wrought to the particular purposes, where wanted; and after the completion of that work, having engaged with Mr. TUCKER as superintendant of his quarries, he had remained there ever since.

108. THE first thing that excited my curiosity, was the very subject I came upon, that is, the quarries from whence the stone sent from Portland is produced.—The upper surface of the island I found was tolerably flat; but elevated above the sea, according to the estimation of my eye, at least 200 feet. The Stratum of stone that is wrought for sale, lies nearly parallel with the upper surface of the island; and with not much cover of earth or rubbish upon it. There are several beds of stone lying in contiguity, one above another, varying in thickness in general from two to four feet and upward. Those which are usually called the merchantable Beds (on account of the blocks for sale being produced therefrom) are universally covered with a Stratum called the Cap, which is formed entirely of a congeries of petrified sea-shells, of a great variety of kinds, but in general so distinct and separate in their forms, that to the curious naturalist, their species seem very easy to be made out\*: but as they in a considerable degree retain their respective figures, (though in some places more, in some less) spaces or cavities are left between them, which consequently very much diminish the coherence of the mass; but yet the cementing principle is so strong, that the whole together is considerably harder than the merchantable beds: and indeed so hard, that to get rid of it as easily as possible, it is generally blasted off with Gunpowder.—Were it not for these cavities, the cap-stone would not readily be worked with tools: or at least it would not be worth working at a place where there is so great plenty of stone of a better quality: but as it is necessary to remove it in the course of working the better kind of stone, though by far the greatest proportion is blasted into fragments, yet for the buildings on the island, the cap-stone is in general use, and also for the piers and quay walls of Weymouth Harbour; as also in the pier for shipping stone at Portland, blocks are used from the cap; and indeed upon the whole, were it not for the expence of freight (which is the same as upon those of the best quality) for various rough purposes under water, &c. the cap would make quite as good and durable work, as the merchantable blocks.

When the merchantable beds are cleared of the cap, the quarry-men proceed to cross-cut the large flats, which are laid bare, with wedges, in the way I have described as to the moorstone; only the wedges are not so numerous, nor does Portland stone split so evenly as the Granite: and frequently in the splitting, as well as other working of this stone, oyster and other fossil-shells are discovered in the solid substance of the merchantable stone.—The beds being thus cut into

\* There are many shells of the spiral kind, called *Corana Ammonis*, some very large, and I saw one which when cleared from all surrounding matter was two feet in diameter.

distinct lumps, the quarry-man with a tool called a Kevel, which is at one end a hammer, and at the other an axe, whose edge is so short or narrow that it approaches towards the shape of a pick\*, by a repetition of sturdy blows soon reduces a piece of stone, by his Eye, to the largest square figure which it will admit; and blocks are thus formed from half a ton, to six or eight tons weight; or upwards, if particularly bespoken.

109. WHEN I viewed the simple construction of their carriages, I could not but wonder upon being told, that such a very plain piece of machinery, was all they had for getting the largest blocks down to the water-side; but when I saw the application, my wonder ceased.—I have already observed, that the plain, upon which the quarries are situated, is considerably elevated above the sea. It is further to be observed, that though the greatest part of the circumference of the isle to seaward is bounded by cliffs almost perpendicular, yet on the North side towards the main land of Dorsetshire, the descent is more moderate, though it is rather quick every where.—It did not indeed at once occur to me, that though it would require a very great power to draw large stones against Gravity, or up-hill; and even a considerable one to draw them upon the plain ground; yet in moving down-hill their gravity would assist them.—The carriages are a kind of Carts, consisting of nothing more than a pair of very strong solid low wheels (as well as I remember) about a yard in diameter, and a very thick axle-tree, upon which is fixed a stout planking or platform, that terminates in a draught-tree for steerage and yoking the cattle to.—The wheels and platform being low, the blocks are the more easily loaded thereon, and a necessary power is employed, according to the size of the block, to draw it to the commencement of the descent.—To this place a quantity of blocks of different sizes have been, at leisure times, previously drawn; and one of these blocks, of a suitable size, such as experience has pointed out, is by a strong chain attached to the carriage, on which the other block is placed, which is then drawn forward with the block in tow, till they are got sufficiently upon the slope of the road, to find an inclination in the loaded carriage to move the attached block; after which all the horses and beasts of draught are taken off, except such as are absolutely necessary for the guidance; and in this way (the descent being continual to the pier) two large stones are got down with a degree of ease and expedition, that would be almost impracticable with one alone, without more complicated machinery.

110. I FOUND I could have every thing here, that I could desire in the freestone way; so far as rough scappelling went; and at a price so moderate when delivered on board, that the freight, even to Plymouth, would be a considerable part of the charge: but that in regard to hewing, after the work of Westminster Bridge was over, the hands brought here on that occasion were dispersed; or the few which were left had engaged to work in the quarries: and that except for such large undertakings as Westminster Bridge, what could be saved in freight, would not compensate the disadvantage of employing separate workmen at a distance: for, in regard to the internal works of the island, there was not enough of them to maintain stone-cutters; and though they had just built a new church, which I observed had been neatly worked, and chiefly from the cap-stone, yet I found that workmen had been brought into the island to perform it.

111. FROM the practicability of the road in the way before mentioned, and also from the circumstance of there being there the quietest water, the pier for shipping the stones is on the north side, adjoining to Weymouth Road; so that the stone vessels, if caught by a storm while lying there for a freight, retreat into Weymouth Harbour.

I did not fail to visit the Lighthouses, built nearly on the highest part of the island; but as they are built upon the dry Land, and burnt coals, I found they contained nothing singular, or material to my present purpose.—The various Strata, of which this island appears to be composed, would furnish speculation to the curious naturalist; but which the purpose of my present visit did not allow me time particularly to attend to: but what struck me most with wonder and amazement was the Portland Beach, which I could not enter the island in crossing

\* The Kevel is a tool curiously formed for the purpose; the face of the hammer end not being flat, but hollowed according to the portion of the surface of a cylinder; this gives a keen edge to two of its opposite sides, that are parallel to the handle, and by this means biting keenly upon the stone, brings off a spawl or large shiver. The edge at the pick end is about half an inch in breadth.



the salt-water creek from Weymouth, without remarking: and which perhaps renders it impossible to decide whether Portland is really and properly an Island or not\*. This work of nature is an immense bank or mound, formed to appearance of round pebbles of promiscuous sizes, the generality not exceeding the size of a pullet's egg; which by the action of the sea in beating them one against another (being of a very hard nature) are worn so smooth and round, that a man can scarcely walk upon them without sinking to the ankles, or a horse to his knees at every step. In consequence of the matter being so loose, it forms a considerable slope, both towards the sea and to landward. It proceeds from the N. W. corner of the isle of Portland, and keeps somewhat near a N. W. direction till it approaches the shore, at (I think) scarcely a mile distance. Had it there actually joined the shore, and had the rest of the beach been heaped upon the natural coast of Dorsetshire, this conformation would not have been a matter altogether singular: but on ascending the summit of the Beach, which is several feet above high-water mark, that I might have a more distinct view of it (which I was fully enabled to do by its being low water when I first landed upon it) I found, that not only the part from the place where I stood, to its junction with the island, made a portion of a regular curve; but that it was continued in a fair Sweep as far as the eye could trace it, nearly parallel to the general range of the natural shore, but without joining it; and in this way I was told it proceeded almost to Abbotsbury, at the distance of 14 miles, and there united with the shore; so that a person chusing to travel upon it from Abbotsbury, might with much labour and patience go to Portland on dry land even at high water.

A work of nature so regular in its form, must necessarily have a regular cause; what this cause may be, seems not very obvious, but it certainly is well worthy the attention of the skillful naturalist.—It would seem not to have had its origin at a very remote period; for the irregularities that the sea had washed in the ancient coast were still very distinct upon the salt-water creek (which as I have already said, every where runs behind it, till its final junction with the shore,) whereas in any great length of time, they must have been so far acted upon by frost, rain and wind, as to have been obliterated; since the present beach, like an immense bulwark, defends them from the immediate action of the sea's making any further incroachments.—It would seem also, that this beach was formed somewhat suddenly; so as to be, as it were, at once a defence to the ancient coast: for had a quantity of pebbles been washed up from the sea, and brought to the shore gradually, there does not appear to be any reason why the action that brought them thus far, should drop them short of the shore, and not heap them upon it; in which case, no salt-water creek would have been formed; for then the little irregular bays in the shore would have been first filled up, and the whole mass brought forward in the same kind of fair curve, as we now find it: but from whence such a mass of pebbles should come, as very soon to form so great a Barricade as to shut out the sea, is a problem not seeming to admit of an easy solution†.

It further appears, that this beach lying in such a direction as to receive the full action of the S. W. seas, the component pebbles are of so loose a nature, that every tide makes an apparent change in the manner of its slope to seaward; which being formed into a sort of steps, or benches, answerable to the last high-water mark, these range regularly for a considerable length, and seldom remain the same for several tides together.—In time of storms, great quantities of the pebbles are driven over the summit, and as there is no power acting in a contrary direction, to bring them back again, one might at first be led to suppose the whole beach to be in a slow state of progression towards the shore, and that in time it would fill up the salt creek: but in contradiction to this idea, I was told, that four, five, or six feet beneath the surface of the pebbles, there is every where a strong mound of blue Clay, having the same general shape as the beach.

\* If an island, with Dr. Johnson, is defined to be a Tract of Land surrounded with Water, then this certainly is not an island; but if it be defined to be a tract of land, whose component Strata are altogether detached from the main land, in this sense it may justly be denominated an island.

† On consulting CAMDEN's Britannia 8vo. edit. 1290, it would seem, that in his time this Beach must have been of far less bulk than at present; as he speaks of its being cut asunder by the action of particular winds, and its being consolidated by others: and that Portland was formerly an island, though now annexed to the continent. His words are, speaking of this beach, "*Fleruoso hinc meatu longe se immittit litus, aggerque CRESILLI dictus ex arenis agglomeratis, freto tenui interfuso per IX. mill. pass. oductus pretenditur, quem noster cum ingruit, plerumque interscindit, et aquilo e contra, consolidat. Hoc aggre PORTLAND quondam insula, nunc continens adnectitur.*" Camb. Brit. page 14. N. B. The first Edition of CAMDEN was in the year 1586.

This one can hardly imagine to be in a moving state: and though there may be an endless succession of pebbles constantly washing up from the sea, to supply the place of those washed over the summit; yet still, why there is not a gradual incroachment upon the salt creek, does not readily appear. Was there any considerable discharge of land water by this creek, that would doubtless keep it clear, and the reflux of the salt water may somewhat tend to the same end; but yet its reflux seems far too languid to be sufficient for the purpose.

112. THOUGH I found my curiosity strongly excited by this singular and surprising work of nature, yet I had not time fully to satisfy myself as to facts; and as I have not since met with any adequate account of it, I am inclined to give a place to such particulars as I could relate from my own observations; as my doing this may excite more able naturalists to examine minutely into the history of it, and it seems very well to deserve a more particular investigation.—As I was struck with wonder at the construction of the Portland beach, I could not be wholly inattentive to an anecdote which occurred here, respecting an equal singularity in the manners and customs of the Portland Quarrymen: for at that time those of the South Sea islanders were entirely unknown to us; and as I do not find the system of Portland has been touched upon by any of our travellers or Tourists, my reader I trust will not be displeased, if I give him a short sketch thereof in a note, as it occurred upon the place\*.

113. HAVING settled my business with Mr. ROPER; that the best way to get our stone rough scappelled, nearly to the shape I required, would be to send rough moulds, ascertaining the figure, with the thickness of the course marked upon each mould, and each dimension to be one inch bigger than the true size previous to being fair worked, we should not by this means have much extra Weight; as only the medium of half an inch on a side would be to cut off, and which would be sufficient to form the true figure; I then took leave of him and this curious island: and though I had every reason to be satisfied both with the material and my correspondent; yet nevertheless in my passage from thence to London, I determined not to leave any thing unseen that might contribute to my information; and for that reason, to take a view of the state of the quarries at Purbeck; from whence, for ages, London had been chiefly supplied with flat paving stones, and steps.

\* When I was looking over the quarries at Portland, and attentively considering the operations; observing how soon the quarry-men would cut half a ton of Spawls from an unformed block, and what large pieces flew off at every stroke; how speedily their blows followed one another, and how incessantly they pursued this labour, with a tool of from 18 to 20 pounds weight; I was naturally led to view and consider the figure of the operative Agent; and after having observed that by far the greatest number of the quarrymen were of a very robust, hardy form, in whose hands the tool I have mentioned seemed a mere Plaything; I at last broke out with surprise, and enquired of my guide, Mr. ROPER, where they could possibly pick up such a set of stout fellows to handle the Kevel, which in their hands seemed nothing: for I observed that in the space of 15 minutes, they would knock off as much waste matter from a mass of stone, as any of that occupation I had ever seen before would do in an hour.—Says ROPER, we do not go to fetch those men from a distance, they are all born upon the island, and many of them have never been further upon the main land than to Weymouth. I told him, I thought the air of that island must be very propitious, to furnish a breed of men so particularly formed for the business they followed.—The air, he replied, though very sharp, from our elevated situation, is certainly very healthy to working men; yet if you knew how these men are produced, you would wonder the less; for all our marriages here are productive of children.—On desiring an explanation how this happened, he proceeded: “Our people here, as they are bred to hard labour, are very early in a condition to marry and provide for a family; they intermarry with one another, very rarely going to the main land to seek a wife; and it has been the custom of the island from time immemorial, that they never marry till the woman is pregnant.” But pray, says I, does not this subject you to a great number of bastards? Have not your Portlanders the same kind of fickleness in their attachments, that Englishmen are subject to? And in consequence, does not this produce many inconveniences? None at all, replied ROPER, “for previous to my arrival here, there was but one child, on record of the parish register, that had been born a bastard in the compass of 150 years. The mode of courtship here is, that a young woman never admits of the serious addresses of a young man, but on supposition of a thorough probation.—When she becomes with child, she tells her mother; the mother tells her father; her father tells his father, and he tells his son, that it is then proper time to be married.”—But suppose, Mr. ROPER, she does not prove to be with child, what happens then? do they live together without marriage? or, if they separate, is not this such an imputation upon her, as to prevent her getting another suitor? The case is thus managed, answered my friend: “If the woman does not prove with child, after a competent time of courtship, they conclude they are not destined by Providence for each other; they therefore separate; and as it is an established maxim, which the Portland women observe with great strictness, never to admit of a plurality of lovers at one time, their honour is no ways tarnished: she just as soon (after the affair is declared to be broke off) gets another suitor, as if she had been left a widow, or that nothing had ever happened, but that she had remained an immaculate virgin.”—But pray, Sir, did nothing particular happen upon your men coming down from London? Yes, says he, our men were much struck and mightily pleased with the facility of the Portland ladies, and it was not long before several of the women proved with child: but the men being called upon to marry them, this part of the lesson they were uninstructed in; and on their refusal, the Portland women arose to stone them out of the island; inasmuch that those few who did not chuse to take their sweethearts for better, or for worse, after so fair a trial, were in reality obliged to decamp: and on this occasion some few bastards were born: but since then matters have gone on according to the ancient custom.

114. HAVING made my entry into the Peninsula, or, as it is generally called, the Isle of Purbeck, by the ruins of Corf Castle; and observing that a considerable part of the out-wall was in a remarkably leaning condition, something like the representation of the leaning tower of Pisa; I stopped to examine the masonry, and particularly the mortar, of a building that was capable of so great a degree of inclination without falling to pieces.—I found its solidity, as usual in ancient buildings, did not consist in having been built with large hewn stones throughout, for the interior filling of the walls was with rough Rubble, and fragments of the quarries; the interstices being entirely filled up with mortar, that undoubtedly had originally been fluid, and in that state poured in; and from the nature of the component matter, as well as time, the whole mass had become strongly cemented together. I found that the mortar was composed of lime (doubtless originally of a good quality) with a considerable admixture of sharp sand and Pebbles.

115. ON going to Sandwich, or, as commonly called, Swanage, the principal town of the quarrymen, and having procured a guide, I first went to view the quarries where the flat paving and steps were wrought. The Strata here are thin, some only of three inches, and seldom any single layer above twelve inches; the whole of several contiguous beds, taken together, being at that time, not much above a yard and an half in thickness. Having a good deal of cover of earth, &c. upon them, they were then chiefly wrought underground; and the whole of the merchantable stone being taken out, the incumbent matter was supported by building rough pillars with stone of an inferior quality.

From observing the nature of the thicker layers of this stone, I was at first led to imagine that this was the place from whence that peculiar kind of marble had been obtained, of which those long, slender, polished columns are formed, that are to be met with in most of the old cathedrals, even at a great distance from Purbeck; and which at those distant places are often taken for an artificial composition\*.—I was shewn a district of ground where flat paving stone had been formerly wrought in Strata near the surface; so that it was then easily come at, and in great plenty; but the continual demand for the London Market, had in a great degree exhausted the quarries so circumstanced, and reduced the product chiefly to what they got underground in the manner I saw; so that the flat paving had already very considerably advanced in price, and was likely to advance still much higher†.

116. FROM hence I was carried to see the quarries where a species of stone was got in blocks, much of the nature and colour of Portland, which is called Purbeck-Portland.—These quarries are situated at, or near the point of high land, about three miles from Swanage, called St. Alban's Head. The strata of merchantable stone lie here in the upper part of the cliffs, as they do at Portland; but having more cover, they are in some measure worked underground. This stone is of the like nature, and puts on so much the appearance of the Portland, that it is often used in lieu of it. It is however inferior in colour, harder to work, and according to the information I then got, not in general near so durable‡. But what seemed to me likely for ever to prohibit this field of stone from coming into competition with Portland, is; that as it cannot bear the expence of land-carriage down to Swanage to be shipped, the workmen are obliged to let it down with ropes from the place where it is wrought, to the surface of the sea, either into vessels lying at the foot of the cliffs where there is deep water, or where there is a dry Strand at low water; but there being little shelter from the winds and seas, this can only be done in very

\* That great naturalist Dr. Woodward, is however, it seems, of opinion, that those slender columns extant in many of our cathedrals, are dug from the quarries of the same kind of stone at Petworth in Sussex.

† About the year 1764 the Calder Navigation in Yorkshire, having been opened, this gave water carriage to London of the immense beds of flat paving (there called flags) from the quarries of Elland Edge and Cromwell Bottom; by which means the schemes for new paving the cities of London and Westminster were carried into effectual execution. This is not a marble or calcareous stone, like the Purbeck, but is of the grit kind; yet of so close and fine a grain, as to be equally strong and durable, and, like moorstone, much less slippery to the shoes when wet. I mean the kind really produced at the above quarries; for there is stone from other places, of the same appearance, furnished to the public under the same denomination, which is much inferior in hardness and durability.

‡ The stone properly called Purbeck ashler, is of the same nature as the flat paving and steps, and sufficiently durable for all purposes; but a great part of those Strata are under twelve inches; yet some of them run to 18 and 20 inches thick, as I am now informed.



moderate weather, and particular winds; wherefore the shipping it there, must necessarily be somewhat precarious. For these reasons, though for the interior works of the Edystone the quality seemed not objectionable, and the stone could be afforded at somewhat less price than Portland; yet from the uncertainty of shipping, being somewhat further from Plymouth, and few hands, comparatively speaking, being employed here, to what were employed in the quarries of Portland\*, it seemed a place much less capable of expediting my orders; and therefore, that Portland was to be preferred: expedition in getting the work forward being of so much greater consequence to what I had in view, than any small difference in the price.

Immediately on leaving the isle of Purbeck, I pursued my journey to London, where I arrived on Friday the 21st of May; having taken no more than five days in performing the whole, including all observations; and nothing further occurred in it which I think worthy the observation of my reader.

#### CHAP. IV.

##### CONTAINING TRANSACTIONS IN LONDON AFTER MY FIRST JOURNEY TO PLYMOUTH.

117. IMMEDIATELY on my return to London, I attended the Proprietors at a general meeting, and laid before them a full account of all my proceedings, and the information I had got in my late progress; together with my observations and thoughts relative thereto, which I have already particularized in the course of my narrative. The great and leading point now to be determined was, whether the house should be rebuilt entirely with stone, or entirely with timber; or partly with one, and partly with the other.—One principal matter to be considered, was that of Time, upon which subject I was fully examined; and assured the gentlemen, as my mature opinion, that if the building was to be entirely of stone, there appeared to me every degree of probability of my being able, not only to complete it in the like space of time, that the former Lighthouses had taken, which was four seasons; but, if required, to exhibit a light upon the building itself in the course of the third.—That upon the same reasonable grounds, it seemed to be equally practicable to raise a building with a stone base, and a superstructure of wood, in three seasons, and to build one of wood in the style and manner of Mr. RUDYERD (with some improvements) in two seasons.—On being examined respecting expence, I observed to the Proprietors, that to make an estimate of a building in each of those ways, was no difficult matter; so far as related to a certain given quantity of materials and the workmanship; but that, as in the progress of the work we should lie so widely open to accidents, I could not undertake to make any calculation of this part, which might not possibly be exceeded tenfold; and consequently could not make any estimate of what the whole expence of any structure might amount to, in such a situation as the Edystone. The whole therefore that I was enabled to say with any propriety was, that they being under the necessity of building the house in one of the three ways; whichever they chose, it should be my most earnest endeavour, not only to perform the work in the most substantial manner, but at the least possible expence, consistent with the necessary degree of firmness to give a reasonable expectation of durability.

118. I MUST here observe to the honour of the Gentlemen concerned, that without debate, it was almost immediately determined to rebuild the house entirely with stone, and in the very

\* It should seem from the printed account of the loss of the Halsewell Indiaman in the month of January 1786, which happened in the neighbourhood of these quarries; that the assistance of ropes, &c. given to that very unfortunate crew, would indicate a greater number of quarrymen than would be inferred from the above account of mine; but it must be observed, that I am speaking of things as they appeared to me above 30 years ago.

best manner.—The particular reason that induced the Proprietors to prefer that method, which undoubtedly would be the most expensive to them, rather than either of those which would be less so; as well as attended with less loss of time, it is impossible for me to pass over in silence.—It seemed very imprudent indeed, as far as their own interest only was concerned, that they should think, in the situation they then were, of launching out into any expences beyond what was absolutely necessary.—The building which had been lately destroyed, had, as already observed, stood near half a century, and had it not been destroyed by Fire, might, with proper attention, have existed much longer. A building therefore upon a similar construction, would most probably last for an equal length of time; or at least as long as their present interest in the duties was to continue, and this would have been sooner executed, and have cost much less than one entirely of stone.—The Proprietors had also, with an equal spirit of generosity, excluded themselves from the reception of all profits, by voluntarily stopping the payment of the duties, till a light could be exhibited, as has been already taken notice of.—The Gentlemen were, indeed, sufficiently sensible, that in all probability, the repairs of a stone building would be less frequent than those of a wooden one; but yet, when necessary, might be much more chargeable, and even supposing they were not so, yet as a stone building would be much more expensive, as well as hazardous in erecting, than any other, they would incur a present certain charge, to prevent a future uncertain one; so that it could not seem prudent, with respect to their own interest, to lay out 3 or 4000*l.* now, with the expectation of saving the like sum in repairs 30 or 40 years afterwards. This therefore was not the sort of consideration that determined the Proprietors to erect a stone building; but their resolution was in reality founded on motives wherein self-interest did not bear any share. They conscientiously considered the intention of the legislature, in originally granting the duties, which they conceived were not given to the honourable corporation of TRINITY-HOUSE, and their Assigns, merely for their own emolument; but granted, through that channel, as the recompence to those persons, who at a great pecuniary risque (besides encountering other hazards) would procure such a degree of security, as might be the means of saving from destruction, on this very dangerous rock, not only his Majesty's fleets, but of preserving the lives and properties of his trading subjects; and at the same time afford the like preservation to the shipping of foreigners. This they considered as the sole intention of the legislature, and that there might be no deficiency on their parts, in advancing so noble, so beneficial, and so humane a design, they determined that this preservative of trade and navigation, should be rendered as durable as Nature and Art could furnish means for doing.—Nor was their public spirit confined to this object alone; for they had launched out into another hazardous and chargeable experiment, to supply the want of so useful an edifice, during the time that should be taken up in building a new house, and preparing it for the exhibition of a light; and that was, by fitting out a vessel for a floating Light: and though this was only considered as a temporary expedient, yet from the nature of the service and situation in which it was to be employed, it was requisite to make the experiment as valid and sufficient, as if its existence was intended to be of long continuance; and therefore of itself was a serious concern. This was actually going on at the very time of a new building's being determined upon as above; and had been a considerable time before, fitting out under the advice and direction of a committee, or of select members of the TRINITY-HOUSE: though till the 12th of May then last past, when the Merchants begun a subscription, agreeing to pay the usual duties, the Proprietors were uncertain, whether there would be a foundation, upon which they might be reimbursed a single shilling.—Even by the prospect which this subscription opened, the Proprietors could not reasonably expect to receive any great advantage by this undertaking; when the nature and hazard of it, as well as certain charge of the Out-fit was duly taken into consideration: and with regard to the Lighthouse itself, the very utmost benefit, that there was any probability might accrue to them, would greatly fall short of reimbursing the difference of expence and time, between erecting a building like the former, and one entirely of stone.

119. SUCH were the prospects of those Gentlemen, and such were their determinations at this time: in recording which, I have strictly adhered to matter of fact. Was my pen capable of it, the Thesis would admit of great embellishment; however it luckily happens for me, that it

does not need it : but the pen being in my hand, even after this long lapse of time : after all accounts closed ; all expectancies ended ; and I may say, after all connection and almost all acquaintance dissolved ; it would yet be a violence to myself, to refrain from doing the Proprietors justice, so far as I have touched upon this head ; by informing the world (that part of it especially which is most nearly interested in navigation and commerce) to whom, and to what principles they owe the present structure of the Edystone Lighthouse.

120. THE materials of which the main body of this house was to be rebuilt, being now resolved upon ; as well as that its outward form should as nearly resemble that of the former one, as I should find consistent with the different nature of the chief material, and the improvements that offered themselves ; to prevent any unnecessary delay in making Estimates, &c. the Gentlemen were pleased to content themselves with such general ideas of expence and time as my observations enabled me verbally to make : I was therefore desired without loss of time, to apply myself to making and providing such models and designs, as should enable me fully to explain my proposition to themselves, and afterwards to such other bodies, as they should think it right to consult : at the same time informing me, that though they were sensible that the season was near approaching in which something might be expected to be done upon the rock ; yet they had such confidence in my judgment, that being now myself apprized of what was to be done, they left both the Time and the Means of its accomplishment to me.

121. ON this occasion I found myself totally unfettered ; and perhaps no resolution of the Proprietors ever more conduced to the ultimate success of the work, than this, which set me so much at liberty. Had they been of the same temper and disposition of by far the greatest part of those who have employed me, both before and since, their language would have been, *Get on, get on, for God's sake, get on!* the public is in expectation, get us something speedily to shew, by which we may gain credit with the public ! This, however, was not their tone, which I looked upon as a happy earnest from the Proprietors in the outset.

I considered, that though we should have a great increase of tonnage of materials to carry out and fix, beyond what former undertakers had had, yet that the whole bulk and weight, even as the building was now to be executed, would in reality be no very great matter ; and that, in the present circumstance, the main object was to digest such a scheme as should go progressively on as opportunity admitted, without being subject to great derangements, or having the same thing to do twice over, on account of mistake or failure of the parts. It was with this general idea of the matter, that I took so much pains, and spent so much time, in getting accurate dimensions of the peculiarities of the rock, as I have already related ; and this part of the work having taken a greater length of time than I expected ; which arose from finding the rock more difficult of access ; and, from its irregularity, requiring a greater variety of dimensions than I had imagined ; yet as I had by perseverance fully accomplished my wish in this respect ; the labour so employed would have been of less value, unless made use of to its proper intention ; which was, that of having an accurate resemblance of the rock at all Times to recur to ; in order that, the effect of any operation might, without going upon the rock itself, be judged of, so far as it depended upon the peculiarity of its form.—I further considered, that though I was now upon the verge of the proper season for action ; yet as we could not expect to carry out any materials, or do any thing more this year, than cut the Rock to such a figure as should suit the building ; and as this figure could not be ascertained, without fully considering and determining the form and dimensions of the building itself, so as to shew the manner in which it was to apply to the rock ; I could readily see that the time which would be spent in such a mature digestion, would be much more than saved by avoiding unnecessary and improper work, upon a body of so hard a texture as that we had to deal with.—Had it been practicable to have cut the rock down to the level of the lowest part of the intended base of the building, little previous contrivance or consideration, would have been wanted for the purpose : but besides that this would have been more than the work of a full season ; the space which had been previously occupied by the rock so cut down must have been made good by fresh Matter ; and that could never be expected to be so perfectly firm and solid, as the unshaken parts of the rock itself ; and besides, we should then have



lost the rock as a Holdfast, and Buttress against the great South-west seas; which, so high as it reached, was of the most effectual kind possible.

It seeming therefore to be a first principle, to cut the rock as little as we could help; and for this end, to humour its irregularities as far as we could, so as to get a firm fixing for our work; on this account it appeared necessary, as the first step to be taken (from the dimensions already obtained, and by the methods already specified) to construct a complete Model of the rock, in the condition I found it: which being done, a second model might then be formed, shewing to what the rock was to be reduced, with the manner of applying the work of the building thereto; and so as to describe the external general form, which would be the whole of what was then wanted, for present determination; and for adjusting the work of the approaching season. These models I determined should be the work of my own hands; and this I foresaw, must in its own nature be a work of Time.

122. THOSE of my readers, who are not in the practice of handling mechanical tools themselves, but are under the necessity of applying to the manual operations of others, will undoubtedly conclude, that I might have saved much time, by employing the hands of others in this matter: and on the idea of the design being already fixed, and fully and accurately, as well as distinctly made out; that is, supposing the thing done, that was wanted to be done, it certainly would have been so: and had I wanted a duplicate of any part, or of the whole, when done, I should certainly have had recourse to the hands of others. But such of my readers, as are in the use of handling tools, for the purpose of contrivance and invention, will clearly see, that provided I could work with as much facility and dispatch as those I might happen to meet with and employ, I should save all the time and difficulty, and often the vexation, mistakes and disappointments that arise from a communication of one's own ideas to others; and that when steps of invention are to follow one another in succession, and dependance on what preceded, under such circumstances, it is not eligible to make use of the hands of others.

I had also a further reason for undertaking this part of the work myself; which those who shall peruse this account for the sake of information, may not be displeased to know.—I have always found in subjects of mechanical invention and investigation, that I can seldom form an original idea so complete, but that by laying it down in its proper dimensions on paper, I could very much mature and improve it; and where the subject is attended with intricacy, it is in a greater degree necessary: but in reducing this to a solid, as is the case in making a model, still further corrections and advantages will often present themselves, that did not appear upon Paper: and this in a much more eminent degree when the solid is produced from the drawing by the artist's own hand, than by the hand of another: and still further improvements will occur, by going again over the detail, in constructing the work itself at large. Therefore to avail myself of all possible advantages of previous light and information, I determined, from the paper materials that I had brought from Plymouth; as well as those I carried thither; at once to construct the models above-mentioned myself; in which work, though I was closely engaged till the month of July; there was no impatience on the part of the Proprietors; as Mr. WESTON visited me almost daily, and was himself witness of the progress.—It may here be proper to say, that though I thought it necessary to employ my own hands upon the models, yet I availed myself of those of others, wherever I found them applicable: for having considered that I could not avoid having occasion for at least one great Purchase-Tackle; I therefore gave out a design to a proper workman, to execute a pair of tackle-blocks, in the style and manner of those I had published the use and figure of in the Philosophical Transactions, vol. 47, for the years 1752 and 1753; only that instead of iron or metal plates for forming compartments for the Sheaves or pulleys, these were constructed with boards for the sake of lightness, and avoiding corrosion by the salt-water. Plate No. 18. contains the design of these blocks\*.

123. IN this interval, however, I took a day with the above-mentioned Gentleman to visit

\* By afterwards employing the late Mr. DUNSTONVILLE, an ingenious blockmaker at Plymouth, upon works of the like nature; a species of new manufacture of ship's blocks has arisen, now, and for a number of years past carried on by the present Mr. DUNSTONVILLE at Plymouth, and Mr. TAYLOR at Southampton.—The term Purchase Tackle has of late years been applied to this kind of blocks.

the vessel then fitting out in the river, for the purpose of the floating Light; and to do this, besides the natural impulse of curiosity, I was desirous of seeing how far its equipment might suit the purposes of a Store-Vessel for our building service.—This vessel was called the Neptune Buss, having been purchased for this service from a great number of busses, that had been fitted out for the Herring Fishery, as a National Concern; which project having then failed, the vessels were sold. The Neptune was picked out as being remarkably well found and roomy, and her burthen, as I recollect, when thus fitted, was about 80 tons.—For this intended service, she had been heightened four Streaks; her deck raised, and laid flush fore and aft; so that if a sea was to break upon her, there would be no lodgment for the water; nor any where for it to enter the vessel, if the hatchways were shut; and those were not spacious: and furthermore in case this vessel was to touch upon the rocks, she would not sink, unless broken to pieces; being so far ballasted and loaded with fir timber, that though there should happen to be free admission of the water through the bottom, she still would be Buoyant, even with her necessary stores on board. This I thought an admirable contrivance for safety in such a service; and though the timber took up a good deal of room, yet in so large a vessel, there seemed to me a probability of there being room enough, both for the lightkeepers, and such of the Edystone workmen as must in their weekly rotations necessarily remain there. I also found her fitted out with an excellent Windlass, and was told, that large mooring chains were preparing: and in every respect, as far as my judgment could carry me, she was exceedingly well calculated for the service intended, and likely to do credit to the Gentlemen who had taken the direction of her works\*.

On this occasion I observed to my worthy employer, Mr. WESTON, that it was probable the fitting out of this Buss, would be a saving of at least 4 or 500*l.* in the equipment of a store-vessel, as I had formerly hinted, in case the corporation of TRINITY-HOUSE should think proper to order the Neptune to be moored within a moderate distance from the rocks, any where to the N. or N. Westward of them; and as this might serve both the purposes, it would greatly relieve the heavy expence they were likely to be at, not only in the floating light, but the stone building.—To this he answered, that as the primary intention of a floating Light, was the preservation of trade and navigation only; and as the corporation of TRINITY-HOUSE, most of whom were bred to the sea, had all along given their advice and assistance in the fitting out of this vessel; so it was presumed they were the proper judges, where it ought to be moored to answer the end best; and that for his part in particular, though he had presumed to suggest a hint to their more mature consideration, yet he by no means wished to bias their judgments, from an attention to the public welfare, by any reasons which might appear to be blended with a principle of self-interest.—However, though thus fully answered, as I was sure it would be no very material impediment to the works, I was determined not to be precipitate in purchasing, or agreeing for a proper store-vessel, till I should know for a certainty, where the floating light was intended to be moored; and by that means give the Proprietors a chance of saving 500*l.* which I judged might be about the sum which a store-vessel fitted separately for our use would cost.—Upon the 8th of July I was informed that the buss with all her men, tackle, and furniture, sailed down the river for Plymouth, but the account of her arrival there (which was on the 17th of the same month) was not returned, while I staid in town.

124. MY models and preparatory matters were now so far brought forward, that Tuesday the 13th of July was appointed by the Proprietors for receiving my explanation of what I had to lay before them. I accordingly attended, and submitted to their inspection a complete model of the house-rock, in the state in which I had found it; and representing all the iron branches broken and whole, of which model, Plate No. 7. contains a reduced plan and elevation: and this was accompanied with another model of the same rock, cut to the intended shape for receiving the building; and therewith connected, a model of the building itself; shewing distinctly how the work was to be adapted to each separate step in the ascent of the rock, as high as I proposed to continue it; and particularly exhibiting the construction of the first entire course, after rising

\* Those descriptions and anecdotes concerning the Neptune Buss, I should have entirely omitted, as being themselves of little consequence now; had it not happened to me afterwards, to have even more connexion with her than I then expected; and as this will save so much explanation and description hereafter, I therefore give this part of it in the order of time.

to the level of the upper surface of the rock; to which a solid being fitted, this model shewed the external form of the whole building, including the lantern; and by a complete section of this on paper, to the same scale, the rooms and conveniencies on the inside were fully expressed: and I must beg leave on this occasion to observe, that it was by now working in the solid, in forming the model for the building, I perceived that for the security of the ground joint, which would be subject to a superior action of the sea, to any other (as lying in the internal angle) it would be necessary, not only that the bed of every stone should have a level bearing; but that every outside piece should be grafted into the rock, so as to be guarded by a border thereof, at least three inches in height before it; which would in reality be equivalent to the founding of the building in a socket of three inches deep in the shallowest part.

125. THE whole having been now fully considered by the Proprietors, the greatest part of whom attended this meeting; they were pleased after a full explanation and discussion to declare unanimously, their entire approbation of, and satisfaction in the whole of my proposition; and therefore desired me to shew my models and draughts, and explain my scheme to the lords commissioners of the ADMIRALTY, and to the corporation of the TRINITY HOUSE: and one of the Proprietors undertook to give intelligence of this to the Admiralty and Trinity House respectively, which he did the next morning; also intimating, that I was then ready to depart for Plymouth, and proposed to do so in a few days; and would wait upon them with my models, &c. when they chose to appoint: and the Proprietors having adjourned their meeting to Saturday the 17th, they concluded that in this time those exhibitions would be over, and the sentiments of those respective bodies known.

The gentleman immediately received an answer in writing from the ADMIRALTY, that their Lordships would be glad to see the models at two o'clock the next day; at which time I accordingly waited on them, accompanied by one of the Proprietors; and must own I was not a little flattered by the thorough approbation their Lordships were pleased to express of my scheme\*.

Saturday came without any other thing intervening, except my own preparations for my journey. I met the Proprietors at the time appointed; but as nothing had then been received from the TRINITY HOUSE, and the season was so far advanced, that all delays were dangerous, in a case where winds and tides were concerned, and the present season in hazard of being in some measure lost; therefore as the Proprietors could not answer it to the public, nor to the corporation of TRINITY HOUSE, if they kept me in waiting; it was determined that I should set forward early on the Monday morning following.

126. DURING the whole of my stay in London, I had kept a constant and regular correspondence with Mr. Jessor, concerning the forwarding of such preparatory matters as I should stand in need of on my return to Plymouth; so that, in that respect, no time was lost.—During this interval, the Proprietors had also appointed a clerk to assist me in all matters of account and correspondence, and in whatever other business I should think proper to employ him. They then proceeded to give me their ultimate instructions, which in one sense might be said to be as particular, as in another they were general; and were nearly to the following effect.—To commence and carry on the works with all possible dispatch.—To employ what persons, and what number of men I should think fit.—To retain, dismiss, or reward them at such times, and on such occasions as I should judge right or convenient.—To agree or contract on their behalf, with any person or persons on any account whatever, relative to the rebuilding of the Edystone Light-house.—To direct the whole business and all persons I employed, and to exercise my discretion in the largest extent.—And, in short, that I was to command without controul except from themselves.

How much soever I was flattered by the thorough trust and confidence that those gentlemen now appeared to have reposed in me; yet I was not less pleased at their delegating one of the Proprietors to act for them in the business of holding a correspondence with me, and managing

\* Lord ANSON was then at the head of that Board, who together with Sir WILLIAM ROWLEY were members of the corporation of TRINITY HOUSE.



and directing all such matters as I should have occasion at any time to resort to them for, of what nature soever: and this judicious measure certainly tended to the speedy advancement of the works; for in many instances while this work was carrying on, had I unfortunately been under the necessity of waiting for a resolution till the individual opinions of all, or a majority of the Proprietors had been taken, much time would have been lost, and possibly seasons; for whatever wisdom there may be in numbers, yet it is a trite and just remark, that they are generally tardy in their resolutions; and delays ought always to be avoided, when it is possible, in matters the execution of which depends on Tides, Seas, and Winds: different judgments and different ideas there must naturally be expected to be among many; but, in such a case, to enter into a debate, as to the propriety of taking any step, perhaps absolutely necessary, and possibly at the very time when that step should be taken, could have no other tendency except to delay and to increase the expence; from the fatal consequences of such circumstances, I was however happily relieved by the resolution of the Proprietors above-mentioned.

127. I AFTERWARDS understood that a verbal message was delivered by the secretary of the TRINITY HOUSE, appointing the Wednesday following for my waiting upon them with the models, &c. but as this would necessarily have created a further delay of some days, the remainder of the season now growing precarious, the Proprietors did not think it proper to countermand my departure; I therefore set out according to appointment, very early on Monday morning the 19th of July for Plymouth; but not without greatly regretting the not having had the opportunity, as well as the advantage, of exhibiting my designs to the Elder Brethren of TRINITY HOUSE: whose approbation as professional men, I was sensible would have greatly contributed to dispel the surmises, and that kind of distrust which must ever hang upon the minds of those who feel their own judgment incompetent; and who yet think themselves called upon to decide on so material a subject as I now had before me, though without having had the opportunity of its being properly laid before them: those, by way of security to their own, generally fall in with the popular opinion; which was, *that nothing but WOOD could possibly stand upon the Edystone*. However I consoled myself with the expectation of having a future opportunity; and that as the whole purport of the present remaining season, was nothing more than cutting the rock to a shape that must in every event, render it more apt for the reception of any structure whatever; I could not fear that any labour would be lost, by any difference in judgment that could possibly happen afterwards.

128. THE models that were prepared and exhibited as above related still remain in my hands, and Plate No. 7. is, as already mentioned, taken therefrom; for being professedly an exact representation of the rock, in the condition I first found it; this admits of no change: but the other model and section, containing the design for the Lighthouse (which as I have before hinted, was subject to some change in entering on the detail of the work at large) no longer remains an exact model of what was executed: nor at the completion thereof, had I any perfect design of it in that finished state; but having taken memorandums of the alterations, I have been enabled to make out a due representation of the work as it now stands: and as the original models, &c. served very well for many years to explain the nature of the work that had been done; the difference not being very considerable, in like manner the present representations of the work as really executed, will equally explain, what was formerly exhibited; first to the Proprietors themselves, then to the lords of the ADMIRALTY, and afterwards to the honourable board of TRINITY HOUSE; who to my great satisfaction entirely approved thereof.

Plate No. 8. contains the elevation or present appearance of the Lighthouse, as seen from the south.—Plate No. 9. contains a section of the whole as seen from the same quarter.—Plate No. 10. contains the plans of the rock as cut into dovetails, with all the courses up to the top of the rock.—Plate No. 11. contains the plans of the first whole or ground course, and of all the courses above it.—And Plate No. 12. is an enlarged plan and section of the lantern.

## BOOK III.

CONTAINING AN ACCOUNT OF PROCEEDINGS, FROM THE COMMENCEMENT  
OF THE WORK UPON THE ROCK IN 1756, TO THE BEGINNING  
OF THE SECOND SEASON IN JUNE 1757.

## CHAP. I.

NARRATIVE OF THE PROGRESS OF THE WORK DONE UPON THE EDYSTONE  
FROM MY ARRIVAL AT PLYMOUTH IN JULY 1756, TO THE  
TIME OF MOORING THE NEPTUNE BUSS.

129. **I** ARRIVED at Plymouth on Friday the 23d of July 1756, having been met by Mr. ROPER at Dorchester, with whom all necessary matters were settled; among which, the price of the stone, the mode of admeasurement, the number of feet (16) per ton, and the method in which we were to receive a regular supply, were not the least material. On my arrival, I found that Mr. JESSOP had completely fitted up, for present service, Hancock's Sloop, which I had before made use of as an attendant; also, the Edystone boat; and a large yawl with sails and oars; and had likewise got other things in forwardness that had been committed to his charge; and I immediately entered another able seaman, which, with our former crew that I had left on half pay, made the number six.

The Neptune Buss I found was arrived, and lay in Stonehouse creek; but without any order for the exhibition of a temporary light: on the contrary, I now understood, that some difficulties had arisen between the Trinity Board, and their lessees of the Lighthouse\*; and that in consequence of this, two of the members of that corporation were then in the country, preparing another vessel for that purpose. It seemed therefore to me most likely, that the Neptune Buss, if not applied as a floating light, would be destined to be a store-vessel for the service of rebuilding the Lighthouse; and this occasioned me still to suspend all orders for the preparation of chain moorings, till I saw the event of this business: but that our immediate service might not be hindered, I ordered the sloop's cable to be very well wormed and served†, and a new one to be prepared in addition, in the same manner.—The weather proved not suitable to go out to sea when I came, and I was informed, that the season had never been very favourable for our service since my departure from Plymouth in May: however, Sunday the 26th appearing promising, though there was but little wind, and being desirous to reconnoitre the place, as our ground cables for the sloop could not yet be got ready, I determined to try what we could do in rowing out in our new yawl, with the aid of such breezes as might happen: the sloop being ordered to follow us as she could; that in case a fresh of wind should arise from the north, which would be

\* Said to be owing to an Application of the Merchants of London to that Corporation, that they would take the proposed temporary light under their own management and direction.

† The worming of a cable is to inlay ropes so as to fill up the spiral furrows between the Strands of the cable, and to bring the surface upon a level; which not only strengthens the cable, but enables it better to endure friction against the ground: and the serving of a cable is the wrapping it round with another rope whose coils are close to each other, like the bass string of a Violin; and to render this still more effectual, the cable is often first bound round with canvas, and then the service-rope wound tight upon it, which was done in the present case.

very unfavourable to our return, she might then get out to sea, and bring us back, or make her course good to land us at Fowey, or some other convenient port.—We went out about eight in the morning; and with four oars, without assistance from the wind, got to the Edystone. I landed there, staid an hour, found every thing exactly as I had left it; and after making some remarks relative to fixing the center of our proposed building, got back to Plymouth at four in the afternoon. In our return we met the sloop in the entrance of the Sound, she not having been able to get any farther.

130. AFTER this day the weather came on bad and rainy, and continued so till Tuesday the 3d of August; which a good deal retarded our work in preparing the cables, &c. However, the interval was of so much length as to allow us to prepare every thing fully for the sea.—I made use of this time also in preparing and establishing our working companies upon the plan I have already mentioned, § 101.—I made choice of and agreed with Mr. THOMAS RICHARDSON, a master mason of Plymouth, of good reputation, to act as foreman to one of the companies; and also with WILLIAM HILL, who had been some time foreman to another master mason of the same place, to act as my other foreman. I likewise entered three masons and nine tinnors\*, as a company to go out with Mr. RICHARDSON to take the first turn or week, commencing from Saturday the 31st of July.—Mr. JESSOP I appointed my general Assistant. The wages of the foremen, while out at sea, were to be 5s. per day certain; and for every hour spent upon the rock, the further premium of 1s. But when employed in the work-yard, or otherwise on shore, their wages were to be 3s. 6d. per day. The wages of the masons were to be 2s. 6d. per day certain at sea, with a premium of 9d. per hour; and the tinnors 2s. per day certain at sea, and 8d. per hour. In the work-yard or on shore, the masons were to have 20d. and the tinnors 18d. per day; and to be paid for over time, when required to work, at the rate of double the price per hour, that their day wages came to, as proposed in my original plan: and that the seamen might not want inducement to do their utmost in landing the workmen at the Edystone as early as possible at every opportunity, and supply them with what was necessary for keeping them at work; over and above their weekly wages, which were settled at 8s. per week, they were all to receive a premium for every landing upon the rock; the master seamen of 2s. 6d. and the ordinary of 2s. to make their advantage equivalent to that of the other workmen, in whatever service the seamen (who were constantly on duty) might be employed.—Mr. JESSOP as general assistant was to have 10s. 6d. per day at sea, and 5s. per day at land, as he had been used to be paid; and every one was to supply himself with victuals.

In this interval I also agreed with Mr. DELACOMBE for half an acre of ground for a work-yard; being part of a field lying on the west side of Mill Bay (as before described, see Plate No. 17, Fig. 1.) which he rented of Lord EDGECUMBE, and which by permission of his Lordship, was to be applied to this use; and I marked out the yard and agreed for the fencing it with boards†.—Within this time Mr. JOHN HARRISON, the person made choice of as clerk to the Edystone works, arrived from London, with whom I digested a plan for the keeping our accounts and correspondence, and for the distinct noting of so great a variety of articles as must necessarily occur, we found it expedient to open no less than 14 different books.

131. MATTERS being thus put in a train on shore, and the weather having become more promising, on Tuesday morning the 3d of August, Mr. RICHARDSON and company embarked in the sloop with her ground tackle‡ on board; attended by myself and Mr. JESSOP, and also the yawl properly manned: the wind was favourable at N. W. on setting forward, but presently changing to W. and afterwards to S. W. our progress towards the rock was not so speedy as we all earnestly wished. Having got within two miles of the Edystone, and the weather being mo-

\* The Cornish miners, as the general produce from the mines in Cornwall for ages past has been tin, are commonly called tinnors; and at this time many of them came to Plymouth to work as labourers.

† Upon this scite the Baths and Long Room have since been erected, as also the Marine Barracks.

‡ The general term for cables, anchors, and all other ropes and furniture for mooring or anchoring of vessels



derate, I went into the yawl attended by Messrs. JESSOP and RICHARDSON, and by the help of oars landed on the rock at half past four, where having brought some tools with us for that purpose, I proceeded to fix the center, and to lay down the lines of the intended work upon the surface of the rock; and being followed by Mr. RICHARDSON, he with sharp picks left indelible traces of those lines, so as to be proceeded upon by the workmen whenever they should be able to land. This work however could not be farther prosecuted for the present; for at six the sea began to be so unquiet, as to make it advisable to quit the rock, and return to the sloop: and before the sloop could gain a proper place for mooring, the sea became so rough, that it was judged impracticable to moor her that evening, or even to lie safely at anchor; we therefore went to Cawsand Bay in hopes of better weather the next morning.

Wednesday the 4th, the wind having continued to blow fresh all the preceding night, and still more so at four in the morning, I returned with Messrs. JESSOP and RICHARDSON to Plymouth in the yawl to expedite matters on shore, leaving the company on board the sloop.—Still the uncertainty of weather seemed to pursue this undertaking; but comfort arose from the reflection that as there had been opportunities to former undertakers enabling them to fix and complete their respective works, it was by no means to be doubted but that circumstances would again occur either sooner or later, so as to allow us effectually to pursue the present intention; and that, whenever we could get a vessel well moored near the rocks, many opportunities would be found of landing and pursuing the work, which otherwise must be lost by our being obliged to proceed from the shore, as was in reality the case in the instance just given.

132. THURSDAY the 5th, the wind being moderate at W. I went on board the yawl at seven in the morning attended by Messrs. JESSOP and RICHARDSON, and on reaching the sloop in Cawsand Bay we immediately weighed and sailed; and arrived off the Edystone at two, when we again proceeded towards mooring the sloop; but before we got our moorings down, the wind again came on so fresh, that we had only the choice of dropping them in a situation not quite eligible, or experiencing a further delay: the former was chosen, as the less of two apparent evils; and upon doing this we found ourselves too near the S. E. reef, in which situation, in case of a hard gale at N. W. and any failure in the moorings, the vessel would be upon the rocks before her sails could be got up and set: however, being free from present danger, and every one anxious to make a beginning, as the tide now served, the whole company landed upon the rock, and immediately began the work, which was pursued for about four hours, when the sea advancing upon us, we quitted the first tide's work at half past eight, with which we had reason to be satisfied. The yawl was then dispatched home with the blunt picks, with orders to return immediately; as the sloop being left with only her small boat, the yawl's service would be wanted the next tide, if favourable to land the company: and to avoid delay, directions were given, that the Edystone boat was to bring out the tools when sharpened.

Friday the 6th, the yawl being returned in due time, all hands landed before sun-rise and worked that tide six hours: in the afternoon's tide, the company landed again, and continued the work, by the light of links, till ten at night. At seven in the evening the Edystone boat arrived with the sharp tools, and was immediately sent back with the blunt ones: and this day I got nearly the whole of the work laid out, as is particularly expressed in Plate No. 10. Fig. 1. which shews the dovetail recesses, and two new steps which were formed below all the former, according as it was ultimately finished for the reception of the stone-work: only that (to save a figure) the first course of stone is here expressed as laid; the doing of which was in reality the beginning of the work of the next season: the whole object of the work of this season being to get the surface of the rock converted from the shape and condition in which we found it, according to Plate No. 8. Fig. 1. to that of the figure just referred to: we also made good dispatch with the cutting of the rock, considering the exceeding toughness as well as hardness of it.

133. IT might seem at first sight, that a greater dispatch would have been made by the use of Gunpowder in blasting the rock, in the same manner as is usual in the mines, and in procuring limestone from the marble rocks in the neighbourhood of Plymouth: but though this is a very ready method of working hard and close rocks, in proportion to the dispatch that could be made

by picks and wedges; yet as a rock always yields to gunpowder in the weakest part, and it is not always easy to know which part is weakest; it might often have happened, if that method had been pursued, that instead of forming a dovetail recess such as was required, the very points of confinement would have been lost.—Besides, the great and sudden concussion of gunpowder might possibly loosen some parts that it was more suitable to the general scheme should remain fast. For these reasons I had previously determined to make no use of gunpowder for this purpose.

134. SATURDAY the 7th, the company again worked six hours in the morning's tide; but this being the day established for the change of the company, they had been but half an hour at work, when WILLIAM HILL and his company arrived in the Edystone boat, with sharp tools, and landed, taking up the tools that RICHARDSON's company had in hand.

Having now completed the lines upon the rock\*, I returned with RICHARDSON and company, leaving Mr. JESSOP to attend HILL and his company for the following week. Our establishment respecting seamen was as follows: three of the seamen being left with the Rock or Out-company; one of them constantly remained in the store sloop; and the other two attended the workmen with the yawl, lying along side the rock at the landing-place in the Gut, to carry any thing that might be wanted to or from the sloop. The other three attended the Edystone boat, being now a passage-boat from the sloop or rock to the shore; and though such a kind of boat was easily managed by two men in ordinary, yet, as expedition was most necessary in the calmest weather, we now allowed three, that two might row, and the other steer.

135. I SHALL in this place take the opportunity of observing, that fine settled weather in these parts is almost constantly attended with Land and Sea Breezes: for about sun-set, or often before, the wind begins to blow a fresh breeze from the northerly points, which is from the land towards the sea; and in one, two, or three hours after sun-rise, it changes to the opposite direction, and blows a fresh breeze from the southerly points, that is, from the sea towards the land: and this circumstance proved in reality one of the greatest advantages towards helping forward our work; as by this means, the Edystone boat was enabled to make one regular trip every twenty-four hours; it being so contrived that she should depart in the evening, and return some time in the forenoon of the next day, sooner or later as the wind and tides served.

136. HAVING given this specimen of the mode of our operations in good weather, it is unnecessary to proceed with the account by way of journal, though I am sufficiently enabled to do it, having kept a regular one from the 23d of July, the day of my arrival at Plymouth to begin the works, to the completion of the same: a copy whereof was made out and sent weekly to Mr. WESTON, for the information of himself and the rest of the Proprietors. I shall therefore now only remark that from the first tide upon the rock, which was the 5th of August, the work was incessantly pursued at the average rate of about five hours per tide, with very little interruption, till Sunday the 15th, when the wind began to blow fresh at S. E. and shall content myself with remarking such occurrences as were more particularly deserving of our notice during this interval.

137. THE very evening I sailed with RICHARDSON, &c. for Plymouth, the seamen on board the sloop discovered a difference in the riding of the vessel, and that in all probability one of the anchors had dragged: and getting sufficient help from the other seamen and company, to heave up the ground cable, they found, that not only the service and worming were cut, but the cable itself was so greatly injured by the sharpness of the rocks, though it had been down not much more than twenty-four hours, that had the weather been rough, it would scarcely have borne to have been heaved up.—Had this not been discovered, as the wind in the night came on to blow

\* Here may be observed the great utility of the time employed in getting dimensions, and forming accurate models of the rock, and of the work immediately connected with it, before the operation was actually begun; for had the contrivance been to make out, while the workmen were upon the place, it is easy to judge of the loss of time, and number of mistakes and incongruities, that must have attended it.

fresh from the N. W. the cable would in all probability have parted, and the vessel gone upon the S. E. reef of rocks; the consequence of which might have been fatal to all on board. Mr. JESSOP, however, after getting the cable refitted in the best manner possible, determined with the assistance of HILL's company, to weigh the anchors and shift the moorings, so that the sloop might have the chance of riding in a more safe situation; that is, at about 100 fathoms to the north of the Gut, where it was judged the rocks might be less sharp, as the soundings were tolerably regular; and where also, in case of breaking loose, a north-west wind would shoot the sloop clear of the house reef. This in reality was every thing that could be expected under such a circumstance: for as a north wind proceeding from the nearest land is productive of the least swell, there would in the distance of 100 fathoms be a probability of hoisting a sail, and steering the vessel clear of rocks, through some of the passages (see the Plan, No. 3): yet after all, without some risque to every individual, there was no prospect of re-erecting the Edystone Light-house. This operation having been performed the same evening, there was little or no time lost to the work upon the rock.

138. ON Friday the 13th, which was in the course of HILL's company's week, the vessel fitted out as a floating Light by the TRINITY-HOUSE, sailed from Plymouth; and being got out to the vicinity of her place of destination, exhibited a light the same evening. Saturday morning the 14th, being the day of RICHARDSON's company going out to change, I went with them at seven, and arrived at the rock at twelve: when I found the seamen on board the sloop busily employed in piecing the ground cable, which this forenoon had again parted, having been cut by a rock in the same manner it had been on that day se'nnight. As soon as the cable was refitted, the moorings were replaced, and at four P. M. I landed upon the rock with Messrs. JESSOP, RICHARDSON, and Co, and staid an hour to examine the work that had been done; HILL's company having worked every tide in the preceding week, amounting to 644 hours: and having found the work properly executed, I returned on board the Edystone boat with Messrs. JESSOP, HILL, and Co, and landed at Plymouth the same evening.—From this view of the work upon the rock, I judged that nearly one-third of the whole was already dispatched.—The great wages that had been made this last week by HILL's company (amounting to above three guineas extra by the foreman, as also by the workmen in proportion) had the good effect of producing so much spirit in them, and that of emulation in RICHARDSON's company to do the same, that we now looked on the performance of the work of this season as quite within our power: provided, that we got a vessel in due time with chain moorings, which could better contend with the rocks, and keep her in her due situation: and as this day the Corporation's vessel completed her moorings, I judged it would not be long before the Neptune Buss would be delivered to my use. This was the more desirable, because the floating Light lying as we judged at the distance of two miles, in a direction W. by N. by the compass, the vessel could not in that situation be of any use to us in carrying on the building, notwithstanding the Light might be in a very proper situation to give timely notice to homeward bound vessels from foreign voyages, they being most likely to be out in their reckonings, in coming into the Channel in foggy weather.—This however occurred, respecting the position of the floating Light; that in case we should happen in our yawl to be caught with a fresh of wind from the Easterly points, so as not to be able to reach our store vessel from the rock, we might find a place of refuge in the floating Light.

139. ON Sunday the 15th, the wind was so fresh at S. E. as to put a stop to the work upon the rock; and in the course of the day the sea became so rough that at five P. M. Mr. RICHARDSON, and the seamen on board, fearing some greater damage might happen to their moorings, slipped their Bridle Cable\*, having put a sufficient buoy upon it, and brought the sloop into Cawsand Bay, where she lay till Monday at midnight; but the weather then mending, they got back to their moorings on Tuesday morning at four, and soon after made a landing; but could

\* When a vessel is moored by laying down a cable upon the ground, with an anchor at each end, then another cable attached to the middle of the ground cable is called the Bridle Cable.



stay only half an hour.—This day I dispatched draughts to Mr. ROPER, according to which the Portland stone for the two first courses above the rock were to be rough scappelled\*; it being agreed on my former interview with him at Dorchester, that in order to save time, draughts for the present would be sufficient.

In the afternoon of the day (Tuesday) that Mr. RICHARDSON and Co regained the moorings, they were able only to work a couple of hours upon the rock, before they were glad to get on board their vessel, and soon after they were obliged to quit their situation, and come again into Cawsand Bay; where adverse weather caused them to remain till Thursday evening; when it becoming more promising, that matters might be expedited as much as possible, I went on board the sloop, and sailed with the company to the Edystone; but found the weather there too violent to attempt any thing upon the rock, or even to lay hold of the moorings; we therefore judged it prudent again to return to Cawsand Bay with the sloop on Friday morning.

Saturday morning the 21st, HILL's company, who had been employed at Mill Bay during the past week in clearing away the mud, and deepening the channel, went in the Edystone boat to Cawsand Bay, and the companies at this time shifted there. In the afternoon HILL's company attempted to go out to sea; but the wind proving too fresh at South, they were obliged to put back. Sunday morning they again attempted it, got out to, and laid hold of the moorings, and landed; but after staying half an hour, were obliged to quit the rock; and in the afternoon, though the weather was fine, and apparently favourable at Plymouth, yet there was so much sea at the Edystone as to prevent their attempting to land. That no time might however be lost, on Monday noon Mr. JESSOP went out in the Edystone boat; but the wind being contrary, after attempting to beat out, he came to an anchor in Cawsand Bay in the evening; and in the night the sloop returned to the same place, having found the ground cable cut a third time.

140. THE next day I received an order from the Proprietors to make use of the Neptune Buss as a store vessel, for expediting the work of the house: I therefore determined to lose no time in getting her out to proper moorings; and having inspected her along with Mr. JESSOP, and found room sufficient in her for the men, without unloading any part of the timber that was in her for buoying her up in case of accident (as has been already mentioned § 123.) we determined to moor her without alteration, except unshipping the tackle belonging to the lantern; which, however, was preserved entire, so that it could have readily been replaced, in case any accident had made it necessary to apply this vessel to the purpose for which she was originally intended.

On Friday the 27th the wind came fair, and the weather moderate; so that HILL and Co went out in the sloop from Cawsand Bay, and got to the Edystone; but the buoys being driven away, they were not able to regain the moorings; they therefore came to an anchor, which enabled them to work every tide while they staid; though on account of the ground swell from the S. W. they made but short tides. During this time the moorings were recovered by sweeping for one of the anchors, and the sloop was once more established thereat.—It was not till Sunday the 29th that the Buss was cleared of unnecessary stores, and fitted for the service of the building; but the weather not suiting to carry her out, RICHARDSON and Co, who were to have gone in her, went out in the Edystone boat. The wind being then moderate, and there being apparently good weather for working upon the rock; finding they made but little way towards it, as the wind was right ahead, the whole company, eager to get upon the rock, took to the yawl which attended them, and making a great exertion, rowed out, and landed about noon, and received the tools from the hands of HILL and Co.

141. TUESDAY 31st. This morning the wind being favourable, the Buss was brought out of Stonehouse Creek; but all, that from circumstances we were able to do this tide, was to warp her out to one of the Transport Buoys belonging to his Majesty in Hamoaze. In the mean time, that no opportunity might be lost to the Out-company on the rock, sharp tools and other necessaries were dispatched in the yawl, along with Mr. JESSOP; who returned the same evening, reporting all well; RICHARDSON and Co being close at work.—Wednesday morning, 1st of

\* A term for such work as could be done with the Kevell before described. See § 109.

September, I went on board the Buss with Messrs. JESSOP, HILL and Co, and four of the seamen. There was a fresh breeze, which not being quite in our favour, we proposed, by making a tack, to get the buss fairly out into the Sound; but in attempting to tack, we found our vessel would not stay, and after endeavouring at it twice more, we were glad to let go an anchor to prevent falling upon the rocks; and thus we lost this day, to our no small mortification: and this was the first of a train of incidents that gave me a less favourable idea of our new vessel than I had preconceived; and in the end satisfied me, that however completely the Neptune Buss was fitted for the service for which she was intended, yet she was not at all adapted to our particular service, insomuch that I had every reason from the sequel to say, that she proved not only the greatest clog and impediment we met with in the whole course of the work, but the real source of almost every disastrous event that happened to us: so that had the Proprietors disposed of her in any way, rather than destined her to our use, the charge of a new vessel constructed upon the plan proposed § 93, would have borne no proportion to the difficulties, disappointments and losses the service in reality suffered from her.

Thursday Sept. 2d. This morning the wind being at N. E. and of course favourable for carrying the Buss out of the Sound, at the proper time of tide we weighed, and sailed about nine in the morning; but before we got out to sea the wind became Easterly, and as we got without the Heads, it came to S. E. so that the wind was then nearly upon our beam, and consequently still fair; but as it was not very fresh, we made but little way; and our way was still less, on account of our vessel being so heavy a sailer: we continued however moving through the water; and as we had reason to suppose the work was going briskly forward upon the rock by RICHARDSON and Co, delays of every other kind seemed within the bounds of patience. About five o'clock in the afternoon, judging the Out-company would be in need of sharp tools, I went in the yawl with one of the seamen and two of HILL's men, got to the rock, landed, and had the pleasure to find RICHARDSON and Co at work, and proceeding properly. In the mean time the Buss came forward, and at eight in the evening, when she was about  $2\frac{1}{2}$  miles from the rock, the wind dying away, and the tide being against her, she came to an anchor; and soon after I returned to the Buss with the blunt tools, and dispatched them with HILL, and four of his men in the yawl to Plymouth, with orders to return as soon as they were sharpened.

Friday the 3d, there being a fresh breeze at N. E. we got under way this morning at five; but it soon becoming Easterly and gentle, it was nine o'clock before we got near the rock: we then dropped anchor, the rock being E. S. E. distant about half a mile. RICHARDSON's company leaving the rock soon after, I sent for some of them to assist in warping the Buss to a proper position for dropping one of the mooring anchors: and being at that time joined by the hands in the yawl, who were now returned from Plymouth, we proceeded to the business of mooring; which to us was a considerable operation: but to make it intelligible to the reader, it will be necessary to describe the nature of the ground-tackle our vessel was furnished with for this purpose.

142. WE had two mooring chains of 40 fathoms in length each; and the bolt-iron of their links being about 1 $\frac{1}{2}$  inches diameter; every fathom of this chain weighed 120lb. so that each chain amounted to the weight of 2 tons  $2\frac{1}{2}$  cwt. and consequently the two chains to 4 tons  $5\frac{1}{2}$  cwt. this, with the two mooring anchors of 12 cwt. each, made the weight of anchors and chains together 5 tons  $9\frac{1}{2}$  cwt. and with the further addition of a large swivel, with shackles and bolts, the weight of iron in this set of moorings might fairly be accounted six tons. The laying these down properly seemed so formidable a business, that I was told by my friends at Plymouth, the force of hands and purchases we had, would never be sufficient for the purpose; but that I should be under the necessity of getting it done by the Master Attendant, and proper people from the King's Yard, with their Mooring Barges, &c. and to this I was seriously advised. I had no reason to doubt of the good will and best assistance of the Commissioner, whenever it was in reality wanted; but always wishing to be master of my own operations, and foreseeing how much delay might arise from the carrying out the King's Mooring Barges so far to sea, where they could not live but in fine weather, I was desirous that the moorings might be put down from the Buss herself; and being clear in the operation, and having the assistance of six able seamen, to-

gether with that of the two companies of stout hands, and the advice and experience of Mr. JESSOP, I proceeded to the business without apprehension of difficulty.

According to the manifest intention of these moorings, the two 40 fathom chains were to be joined together by one of the loops of the large swivel, the other end of each chain being attached to its respective mooring-anchor; one of the anchors therefore being laid to the westward (or down channel) from the swivel, and the other anchor as much to the eastward, or up channel from the same; the bridle cable proceeding from the bows of the vessel, being bent, or annexed to the upper loop of this swivel, the vessel would ride thereby fairly in the middle between her two anchors. It occurred to me, however, that according to this construction, either a considerable part of the two chains must be hoisted, and kept suspended above the ground by the bridle cable, and hang continually upon the bows of the vessel, or else, if the swivel, in the up and down motion of the vessel by the waves, was suffered to strike the ground, that there would be danger, not only of cutting the cable, but of breaking the swivel, by its violently pitching upon the rocks in storms and hard gales of wind. To prevent this, I considered, that the sea being liable to come much more heavy and violent from the western than from the eastern points of the compass, if 40 fathoms of chain were competent to the strain from the West, 40 fathoms would be more than sufficient to resist the strain from the East; and consequently five or six fathoms of it might be spared to act as a bridle; so that, instead of having the two chains joined by the swivel, the western chain should be joined to the eastern at five or six fathoms from its extremity, by a bolt and shackle, and the swivel be applied to the end itself. Thus the western chain of 40 fathoms lying upon the ground, and 34 or 35 fathoms of the eastern also, and the bridle cable being attached to the upper loop of the swivel, when the vessel was riding at her moorings, there would be five or six fathoms of chain, besides the swivel, between any part of the cable and the ground; whereby not only the swivel itself would be preserved, but the cable would be prevented from ever touching the rocks. Having prepared our ground tackle according to this plan, we proceeded to lay them down as follows.

143. OUR vessel was anchored too much to the westward. Soon after RICHARDSON'S company came on board, it became tide of flood; and the water having risen half its height, agreeably to what was mentioned, § 3. it would then begin to run from West to East; and therefore, lest when we weighed anchor we should drive eastward with the tide, and overshoot our mark, we immediately let go another small anchor or Catch, and paid out the Hawser\* by which we were riding; at the same time paying out the hawser of the catch-anchor; by which means the vessel drove eastward till the whole of the first hawser was run out: we then weighed our first anchor (by means of its buoy-rope with the yawl) and heaving in its hawser short, we again dropped the first anchor, and paid out the hawser of the other; and thus alternately, weighing and paying out, the Buss drove to her proper place, to the north of the rock; where, at the distance of about 300 fathoms, we found 20 fathoms water.—At this depth I thought it imprudent to drop our mooring-anchors, in such manner as with their chains to run amain; as this might break the anchor by its fall upon the rocks; or by cracking it we might afterwards be deceived: so I took the resolution (in order to prevent damage) to lower the anchors and chains leisurely and gradually.

The windlass of our Buss, though a very good one for general use, was totally unequal to such a purchase; and here indeed we should have been at a stand, or obliged to run some risk in case we had not been better provided than my friends at Plymouth were aware of. This furnished the first occasion of using the large purchase tackle of 20 sheaves, that I got prepared while in London, and which is mentioned § 122. Those blocks being reeved and brought together, we fixed the standing block to the stern timbers of our vessel, and discharged from one of the bows one of the mooring anchors, attached to its chain, which went over a strong iron roller very well fixed, and secured upon a Davit†, in place of the Hawse hole, intended for the

\* A rope of a smaller size than the cable, and laid or twisted in a less degree, so as to become more soft and pliant.

† A piece of strong timber overlaying the bows of a vessel, containing sheaves, or a roller for purchasing the anchor; its tail being securely fixed upon the Deck.



bridle cable to bear upon, and facilitate the getting in of the cable, or weighing the moorings. The anchor thus discharged remained suspended by about two fathoms of the chain, which, after having passed the roller, was stopped from running further out by strong Salvagees\*; then bringing the chain along the deck to the moveable purchase block, and hooking it to one of the links, we lowered the anchor perfectly at our ease, again stopping the chain with the salvagees, when the moveable block was come near the Davit; and then extending the chain upon the deck as before, the block was again hooked; and in this way we proceeded flitting the tackle and lowering till our anchor was grounded. As we foresaw that the tide running eastward would be far spent before the first anchor was got to the ground, we previously determined to put down the eastern anchor first: and it was grounded somewhat before the turn of the tide to the West.

In this position we staid till Still water, and then having got the hawser of the small anchor through the stern opening, and forward to the windlass, we were thereby enabled to heave the vessel astern westward; in which we were soon assisted by the tide: and thus, the chain being paid out, under the command of the great blocks, and the vessel being heaved westward by the hawser, the whole of the chain was laid upon the ground in a straight line East and West: and it is obvious, that after the whole of the eastern chain was let go, as far as its junction with the western chain, and that junction was completed, then the five or six fathoms of the eastern chain reserved for a bridle, as well as the bridle cable affixed thereto, must be paid out, or let go with the other.

We proceeded as above till the whole of the western chain was gone out, except as much as was necessary to reach to the ring of its intended anchor; which being upon the bow of the vessel, and necessarily at some distance from the davit-roll, here occurred a difficulty in getting the whole grounded in the same leisure manner, without the risk of letting the anchor and 20 fathoms of the chain go over board all together.—For this purpose, we got the anchor as near the bowsprit of the vessel as possible; and passed a small rope several times round the arms of the anchor, and round the bowsprit of the vessel, as close as possible to the stem upon which it rested, and made it very secure: we then let go the anchor from the bow, which of course became suspended by the bowsprit, with the Peak upwards, and just above the water's surface. We now lowered the western chain till it became suspended by the anchor; which, with the chain down to the ground, now hung at the bowsprit. In this situation a strong hawser, of a sufficient length to reach to the bottom double, being passed under one of the arms of the anchor, and the two parts being brought together over the davit-roll, and to the main blocks, the whole suspension was in that manner purchased; and the small rope being loosened, the anchor and chain were then let down by the double hawser: and still heaving the vessel westward, this western anchor was quietly laid upon the ground; and both ends of the double cable being on board, we were enabled, by letting one part go, to free it of the anchor.—We were so fortunate as to have an exceeding fine and calm day for this operation; by which means the whole was performed without the least accident.

144. ON Saturday the 4th of September I landed at six A. M. and found the work to be in the following state. The two new steps at the bottom, and all the dovetails were roughed out, and some of the beds brought to a level and finished; and I judged that full one half of the work I intended to be done on the rock this season was completed.

While I was upon the rock, Mr. JESSOP, the seamen, and HILL's company were employed on board the buss, heaving in the stray cable, weighing the anchors, and getting the buss to rights at her moorings. The tide's work being done at ten, I returned to the buss with RICHARDSON and Company, and in the yawl to Plymouth; which passage, being in a calm, was rowed in four hours.—On Monday evening the 6th the sloop was brought home, and the seamen reported, that on weighing her anchors, they found the ground cable almost cut in rags from end to end.

\* Salvagees or Salvagees are ropes made with the yarns laid parallel and untwisted; being slightly bound together by passing a single yarn round the bundle, which renders them not only the most pliable of all others, but the strongest possible to be made with that number of yarns. Properly speaking, they are in the form of loops, or endless ropes; being made by passing a yarn round two fixed pins, as many times as is judged necessary for the strength intended; the distance of the pins regulating the length of the loops according to their use.

CHAP. II.

SEQUEL OF THE OPERATIONS UPON THE ROCK OF THE FIRST SEASON  
OF 1756.

145. **OUR** Buss being now satisfactorily moored, and a regular intercourse established between her and the shore, there was nothing to hinder the companies from changing regularly every Saturday, except bad weather; nor from working upon the rock, whenever the least interval of good weather concurred with a proper time of the tide to render it practicable: it will therefore now be only necessary to recount such circumstances as happened out of the usual course of proceedings; or such as may deserve particular notice.

On Tuesday the 7th I dispatched to Portland the draughts for the six foundation courses, that were to be employed in bringing the rock to a level; which, with the draughts for eight that I had before dispatched, completed the order for the whole quantity of Portland Stone to be used in the solid up to the entry door; being all that we could expect to set in place, the next season. The rock was not indeed yet ready for completing the exact moulds for those stones that were to fit into the dovetails made in it: but by ordering the stones large enough, and being scappelled something near their proper form, it would prevent loss of time in waiting to get the true figure from the rock, as well as unnecessary waste.

146. **NOTHING** happened to prevent the companies from working every tide from the 27th of August till the 14th of September, in which time they had worked 177 hours upon the rock.—In this interval, having procured a carpenter to be applied to that purpose, I began to make the moulds for the exact cutting of the stones to their intended shapes. This was done by laying down in chalk lines upon the floor of a chamber the proposed size and figure of each stone, being a portion of the plan at large of the intended course; and the carpenter having prepared a quantity of Battens, or slips of deal board, about three inches broad, and one inch thick, shot straight upon the edges by a plane; those battens being cut to lengths, and their edges adapted to the lines upon the floor, and properly fitted together, became the exact representatives of the pieces of stone whose figure was to be marked from them, when their beds were wrought to the intended parallel distance.

It is obvious that there was no necessity for making moulds for a whole course after the work became regular; as was the 7th course, after the six foundation courses brought the rock to a level; it was sufficient to make one mould to each circle of stones, beginning with the centre stone; but as the six foundation courses were adapted to the particular irregularities of the rock, and consequently could not be strictly regular, it was necessary that a separate mould should be made for every separate stone, composing that part of the work.

147. **DURING** this interval I visited the rock, and on arriving there the 8th of September, was informed by Mr. JESSOP that the preceding evening, there being a very strong tide, and no wind, a West Indian homeward bound, and a man of war's tender were in great danger of driving upon the N. E. rock; but that he timely perceiving their danger, though they themselves were not aware of it, ordered out the seamen and hands, who towed them off.

On this visit I staid two days; for as the working company had begun to take down the upper

part of the rock, it was necessary to concert, and put in practice the proper means of doing that, without damage to what was destined to remain. I have already mentioned my resolution of not using gunpowder; yet it was necessary, for the sake of dispatch, to employ some means more expeditious, than the slow way of crumbling off the matter, by the blunt points of picks.—It has been already noticed, that the Laminæ composing the rock were parallel to the inclined surface: and it was very probable that the chasm, into which Mr. WINSTANLEY's chain had been so fast jambed that it never could be disengaged, extended further into the rock than the visible disunion of the parts: this made me resolve to try a method sometimes used in this country, for the division of hard stones, called the Key and Feather; in order to cross cut this upper stratum of the rock. The construction and operation of the key and feather is as follows. A right line is marked upon the surface of the rock or stone to be cut, in the direction in which it is intended to be divided. Holes are then drilled by a Jumper at the distance of six or eight inches, and about 1½ inch in diameter, to the depth of about eight or nine inches; the distances however of the holes and their diameters, as well as their depth, are to be greater or less, according to the strength of the stone, in the estimation of the artist directing the work. The above dimensions were what we used on this occasion. The Key is a long tapering wedge of somewhat less breadth than the diameter of the holes, and so as to go easily into them; the length being three or four inches more than the depth of the holes. The Feathers are pieces of iron, also of a wedge-like shape; the side to be applied to the key being flat, but the other side a segment of a circle, answerable to that of the holes; so that the two flat sides of two feathers being applied to the two flat sides of the key; and the thick end of the feathers to the thin end of the key, they all together compose a cylindric, or rather oval kind of body; which in this position of parts is too big to go into the holes by at least one eighth of an inch; that is, in the direction of a diameter passing through the three parts; but in the other direction is no broader than to go with ease into the holes. A key and a pair of feathers is made use of in each hole; and the feathers being first dropped in, with the thick ends downwards, the keys are then entered between them; the flat sides of all the keys and the feathers being set parallel to that line in which the holes are disposed: the keys are then driven by a sledge hammer, proceeding from one to another, and being forced gradually, as in splitting of moor-stone, the strongest stones are unable to resist their joint effort; and the stone is split according to the direction of the original line, as effectually, and much more regularly and certainly, than could be done with gunpowder, and without any concussion of the parts. Had our rock been entirely solid, this way of working might not have been applicable, on account of the crack's going too deep; but here, when it arrived at the joint where the chain was lodged, the split part became entirely disengaged from the rest; and in this way we were enabled to bring off the quantity of several cubic feet at a time: and thus the chain was released after a confinement of above fifty years. The impossibility of disengaging it before now appeared very evident; for the pressure had been so great by the rock's closing upon it, as before suggested, that the links in their intersections were pressed into each other, as completely as if they had been made of lead; though the Bolt iron composing the chain had been at least five heights of an inch in diameter.

148. ON Tuesday evening the 14th of September there came on a hard gale of wind at the S.W. and on Wednesday the 15th, though the weather was moderate, yet the ground-swell, raised by the S.W. wind the night before, prevented any landing upon the rock. This being the first fresh of wind since the Buss was moored, those on board were not a little attentive to her.—On Thursday the 16th I again went off to the rock, and landed, finding RICHARDSON and Company at work, though it was the first tide they had landed, since the 14th: they acquainted me that the Buss had rode perfectly easy in the gale of wind they had had, and that there was no occasion to veer out any more cable than she usually rode with; which at first had been hawled in so tight as to keep the swivel from the striking ground, when right up and down. I found the work now in the following situation.—The lowest new step (the most difficult to work upon, because the lowest) with its dovetails quite completed.—The second step rough bedded, and all its dovetails scappelled out.—The 3d step (being the lowest in Mr. RUDYERD's work) smooth bedded, and all the dovetails roughed out.—The 4th in the like state.—The 5th rough



bedded, and dovetails scappelled out:—And the sixth smooth bedded, and all the dovetails roughed out.—Lastly, the top of the rock, the greatest part of the bulk whereof had been previously taken down by the Key and Feather method as low as it could be done with propriety, was now to be reduced to a level with the upper surface of the sixth step; the top of that step being necessarily to form a part of the bed for the seventh or first regular course; so that what now remained was to bring the top of the rock to a regular floor by picks: and from what now appeared (as all the upper parts, that had been damaged by the fire, were cut off) the new building was likely to rest upon a basis even more solid than the former ones had done.

149. FROM the time of the hard gale upon the 14th, we found ourselves got into a series of unsettled weather; yet the season did not seem so far spent, but that we might reasonably expect a return of the land and sea breezes, which constantly attended our works whenever they went on uninterruptedly upon the rock; we therefore kept ourselves in constant readiness to seize the lucky minutes, that the works of this year, now brought very far forward, might be perfectly completed.—I attempted to go off several times, but was as often forced to return, until Thursday the 30th, when I landed on the rock with RICHARDSON and his company; but as only about 20 hours work had been done upon the rock since I was there before upon the 16th, I could not expect to find much change in the appearance. However I traced the outlines upon the upper part of the rock for the border of the seventh course, all within which was to be sunk to the level of the top of the sixth, and all without to be left standing as a border for defence of the ground joint of the work with the rock; and measuring the height of the top step above the bed of the first, I found it to be eight feet four inches; which would now be the difference of level, between the west or lowest side of the new building, and the east or highest.—On the company's returning on board the Buss after this tide's work, the yawl's grappling got so fast among the rocks, that it could not be weighed; but in the attempt, it parted the grappling rope: we therefore now laid down the Buss's catch or Kedge anchor a little to the North of the Gut, that is, about 40 fathoms without the mouth of it\*; and having bent to it a part of a sufficient Hawser with a large buoy at the top, that when any vessel went in, she might make fast to this buoy, instead of dropping her own anchor, or grappling; this for the present completely answered the purpose of the Transport Buoy, mentioned § 102. as intended to be placed there.

150. ON Saturday, 2d October, there being a hard gale at S. W. RICHARDSON and company having no sharp tools, or weather to work in, came home in the great yawl, leaving the Buss to the care of the three seamen. In their way home they met Mr. JESSOP with HILL and Company in Cawsand Bay; who had set out that morning to relieve them; and where, after this attempt, they remained wind-bound for two days, and then were forced to return to Plymouth; so that now both companies were at home together, and employed upon the works in Mill Bay.

The unfavourableness of the weather retarded our operations upon the rock for some time, insomuch that, upon the 8th of October, the three seamen who had been left in the Buss (having first secured every thing on board in the best manner they could) returned to Plymouth in the little yawl; having put up an oar for a mast, and a blanket for a sail. This they were under a necessity of doing; for as no boat had been able to get out to relieve them, since the departure of RICHARDSON's company, they had nearly exhausted all their provisions. In their passage home they met the Edystone boat going out with HILL and Company, who got on board the Buss that evening.

151. THE equinoctial winds that now were reigning afforded me but little prospect of doing much more work upon the rock this season; for though a more moderate interval of weather might be expected, after those winds were spent, before the winter came on; yet as this might probably be exhausted in finishing the rock complete for receiving the stone the beginning of next season, we might find it a difficult matter to get the Buss's moorings weighed, after that was done; as it would require the same good weather to take them up, as to lay them down; I there-

\* Near where the sounding 15 (fathom) is marked on the general plan of the rocks; Plate, No. 2

fore began to consider whether this operation might not be dispensed with; conceiving that if a chain was affixed to the swivel, of a sufficient size to support so much of the main chains, as must be raised from the ground, by bringing the swivel to the surface of the water; then a large buoy (which would next year serve for the intended Transport Buoy) being fastened to the top of this subsidiary chain; the main chains, on taking away the bridle cable, might be lowered to the bottom by this buoy chain; and the buoy thus riding all winter by its own proper chain, would afford us an easy means, not only of unmooring the Buss this autumn, but of mooring her again the next spring.

After advising with Mr. JESSOP on the practicability of this method, and probability of its success, I immediately bespoke the buoy chain; which, as it must be made at Plymouth, would take some time; to save which, by reducing its length, Mr. Jessor proposed that we should be content with eleven fathoms of buoy chain to be attached to the swivel, and the rest of the necessary length for riding the buoy, to be of cable; which never coming to touch the ground, he conceived, that the buoy might ride out the winter just as well as if it was attached to a chain only. He farther proposed to fix an under-buoy at the top of the buoy chain, which would in part support it, and being eight or nine fathoms under the surface of the sea, would be in a region of much greater quietude than the surface, in time of storms; on account of which the upper or floating buoy might be the less, and therefore be less subject to any misfortune: and also if by any mischance the floating buoy should break loose, or be carried away, still the under buoy would support its chain, so as to ride some fathoms from the ground, and in that case it might easily be recovered by Sweeping\*.

152. ON the 13th of October, the wind blowing very hard, the great yawl in riding at the stern of the Buss broke loose, having parted a double hawser, and driving away at the rate of four miles an hour, it was impracticable to follow her in the little yawl, which was then on board; and notwithstanding the speediest, and most diligent enquiries after her, we never could hear of her again. This was a real loss, as it had proved a boat particularly adapted to our use.

The weather continued so variable and uncertain during the whole month of October, that the out-companies had worked only 23½ hours.—It was Wednesday the 27th before I saw any chance of going off to examine the state of the work; and this day, the weather being moderate, I went off, and got out to the Buss, but could not land. RICHARDSON acquainted me that his company had worked only 2½ hours this turn; for though they had tolerably fine weather over head, yet the sea had become so long in settling at this advanced season, that they were obliged to return to the Buss, after two strenuous but unsuccessful attempts to land. He further reported, that there was now very little wanting to finish the work of the season, but the levelling of the top of the rock. He also acquainted me, that the seamen, by the help of the company on board, had heaved up the bridle chain, till they could see the Clinch of the cable to the swivel; and found it somewhat damaged, as they judged by having touched the rocks; but the weather coming on rough before they could do any thing at it, they were obliged to lower it as it was; two days after however they again heaved it up, and repaired the clinch. The Buss in all the past bad weather had indeed rode it out to admiration, having never shipped any water, or needed the bridle to be veered out.

153. I NOW considered, that nothing remained to be done of this season's work, that could possibly hinder the beginning to set the foundation courses, at the commencement of the next season; as the top of the rock could be brought to a regular floor, and the dovetails in the upper steps corrected, in the intervals that would necessarily happen, while the lower courses were setting. It therefore seemed unprofitable to continue the companies longer in a state of hardship, merely for the sake of having it to say, that the Year's Work as intended was entirely completed; in consequence I was much inclined not to send out any more hands this season; and ordered Mr. RICHARDSON to return with his company at the conclusion of their week, though the other company should not go out to relieve them; which he did on Saturday the 30th, and brought word that they had worked four hours the day after I had left them; and I could not

\* The operation of Sweeping will be fully explained hereafter.

but notice, that on this day it was remarked at Plymouth, how very unpromising the weather was for our business; such difference is there, in our climate, in a small space between the land and the sea; and such especially between Plymouth and the Edystone; and this shewed still more strongly the great advantage of doing our work by a Store Vessel, in preference of separate voyages.—Mr. RICHARDSON also reported that both the buoys had broke loose from the mooring anchors, but that every thing else was well.

154. HAVING received advice from Mr. TUCKER that three vessels were ready to load with stone as soon as the weather would permit them to go to the pier, we now pushed forward the completion of the work-yard, with its machinery, and conveniences, (See Plate No. 17.) as also the channel up to the Jetty Head, so as to be ready to receive the Portland vessels: and that we might have an assurance of the strength, and sufficiency of our shears, and tackle for heaving the stones they should send us, I made the following trials.—First, I tried them by a strain from the Capstand equal to what would be required in heaving the largest stones intended for the Light-house: then by a strain double the former; after that by one treble; during all which every thing stood firm; but on applying a quadruple force, a great hook upon which the large purchase blocks were hung, gave way, by becoming straight, as if it had been a piece of lead; but no other damage was done: so that I was now well assured of the firmness of all the material parts, as relative to the force to be employed, when in proper use: for from the above trials every thing stood fast with eight ton weight upon the tackle-blocks: and now the work-yard was ready for receiving the stone.

155. THE month of November setting in with a better appearance of weather, HILL's company desired to take another turn, which was granted.—On Sunday the 7th, I went off in the Edystone boat with Mr. JESSOP, and carried out battens, and the carpenter, to mould off the dovetails from the rock: but there being but little wind, it was evening before we arrived at the Buss. HILL informed me that they had worked Thursday night and Saturday afternoon tides, that they had had violent weather on Friday, but rode it out without fear or danger; not having veered out any more cable, or shipped any water; agreeing with what had been reported by RICHARDSON. At twelve o'clock at night I landed with Mr. JESSOP, HILL and Company, and the mould-maker, with the battens; the Company staid 2½ hours, but the night not proving favourable to make much progress with the moulds, I fully explained my meaning to Mr. JESSOP; and left full directions with him about that business, which I doubted not, but his known care and exactness would complete to my satisfaction, if the weather gave leave after my return. On landing upon the rock this tide, I found the work as follows: viz. four or five of the dovetails in the upper steps wanting some small amendment, that would employ as many men at each for about four or five hours. The greatest part of the top of the rock was now brought to a regular floor, but some part of the N. E. side wanted bringing down to a level.

156. ON the 12th of November the buoy-chain for our Buss's moorings was completed; and upon a trial thereof by means of our purchase tackle at Mill Bay, in manner as before, I found it to bear a strain of six tons without any appearance of giving way, which I deemed fully sufficient.—Supposing that HILL's Company, who were now going on in a second week, might want provisions, as also Mr. JESSOP who was with them; the next morning (Saturday the 13th) I ordered out the Edystone boat, but meeting with bad weather, after beating all day and night, it was obliged to return upon the 14th.—On the 15th I ordered the Edystone boat to make another attempt early in the morning, and to get out, if possible; she sailed, but the wind coming South, and continuing to blow hard, she could not get out to sea; and at three o'clock this afternoon we were surprised by the arrival of the Buss, which came to an anchor at the mouth of Mill Bay. Mr. JESSOP informed me, that having scarcely one day's provision on board, and the weather then being, and seeming likely to continue so bad, that no boat could come off to them, and the wind standing fair for bringing them in (not having any boat, in which they could venture home) they all agreed to slip their cable and carry the Buss into harbour, lest the wind should come foul upon them, after their provisions were all spent.—Accordingly, after having



fixed buoys upon the cable, and secured them as well as they could, they set sail for Plymouth this forenoon: but though the wind blew a hard gale, and they came in right before it, they could not sail at a greater rate than three miles an hour. When they came abreast of the Ram-head, they met the Edystone boat endeavouring to beat to windward, which was able to make but little way; and the purpose of the voyage being now over, they returned in company with the Buss.—Mr. JESSOP further reported that the weather had never permitted them to go upon the rock since the night of Sunday the seventh, when I was there; which, notwithstanding all the bad weather, was the only entire week since the commencement of the work, that one company or the other did not land; and it appeared by the account, that since the 2d of October, being 40 days, the whole of the landings amounted but to  $38\frac{1}{2}$  hours. Considering therefore the rock-work to be now as good as finished, I was thankful that we had in reality got through what might be justly esteemed the most laborious and difficult part of our work.—Every thing was said of the ease and buoyancy of the Buss's riding at her moorings in all weathers, though nothing could be said in favour of her as a Sailer.

157. THE Buss being thus prematurely arrived, there was a necessity of carrying her out again for the purpose of fixing the buoy-chain of the moorings: we therefore determined to warp her up to our Jetty Head in Mill Bay, that her bottom might be cleaned, previous to another voyage; and indeed on laying her upon the ground, she appeared very much to need it; for though she had been out of harbour but eleven weeks, the foulness her bottom had contracted was amazing; for it was found to be grown over with a kind of sea-weed, resembling Hog's Bristles; which in some places were near six inches long. From hence I could not help concluding, that though vessels while under sail in performing their voyages, do in time get much foulness, yet in fact, their motion through the water rubs off many of the tender filaments of the weeds, which prevents their growing so rapidly as when a vessel lies in the water, with a much less degree of relative motion; as is the case with those at moorings, though in a Tide's-way.

158. ON Sunday morning the 21st of November, the Buss being cleaned, and prepared for the sea, and the wind fair for going out, I sailed in her at four in the morning with Mr. JESSOP, HILL and Company, and four of the seamen; the other two with a part of RICHARDSON'S Company being in the Edystone boat. As the wind was moderate at E. though our Buss was now cleaned, and the Edystone boat had us in tow, yet it was twelve o'clock before we arrived at the moorings: we had however a hindrance in our passage of about half an hour, by an accident to one of the seamen, who in endeavouring to climb up the mast of the light yawl to rectify something, as he had been used to do in the large one, the boat oversetting he fell into the sea: as the weather however was moderate, nothing further than a wetting was the consequence.

In getting in the bridle cable by means of its buoys; it being a ten-inch cable, having been very hard laid at first, and having become harder by lying in the water, it was found to be so excessively stiff and troublesome to manage, that it was the work of all the hands for the whole afternoon. In one place we found it damaged by fretting against the rocks, but being much longer than experience shewed to be necessary for us, we cut it at the damaged place.—After refreshing ourselves, we began in the evening to heave up the ground chains by the bridle, which employed all the hands for several hours; for though the operation of our large purchase-blocks was very sure, yet having so many times to stop, overhawl, and flit, (as described in laying down the moorings) to get in above 20 fathoms of bridle, the work could not go on very speedily; and indeed without the purchase-tackle, we could not have done it at all: however, at three o'clock in the morning of the 22d, the swivel was got above water.—At this time the wind blew a smart breeze at E. which gave us so much motion, that we found it exceedingly difficult, especially as it was very dark, to get the forelock of the bolt and shackle clinched, by which the buoy chain was attached to the great swivel: this was however effected; and as much depended upon it, I did it myself: but as from its stiffness we found it equally difficult to get the bridle cable unbent from the swivel, and the men being much fatigued by the previous operations, it was thought best to let all stand as it was till day-light.

At day-light the 22d, the wind blew very fresh at S. E. so that it was with great hazard, that

the Edystone boat lay alongside the Buss to deliver the great buoy on board: this was however done without mischief; but it then came on so very fresh, that it became expedient for the Edystone boat to return home for her preservation; first receiving orders to come out again as soon as the weather would permit, in case we did not follow her. The wind being now equally favourable for carrying in the Buss, and still increasing, to save time it was agreed to cut the clinch of the bridle cable, and lower down the ground chains by the buoy chain, in the same gradual manner in which they were heaved up; and by twelve o'clock we had lowered it twelve fathoms: while this was doing, one of our yawls broke loose, and before we were aware that it was gone, had driven away too far for us to attempt to recover it.—On driving a bolt through one of the links of the buoy-chain, (intended as a stop to the under-water buoy as before mentioned) we discovered a flaw in that link, which, though it did not appear of great consequence, yet deserved consideration, and, if possible, amendment: but as no extempore remedy, that could there be applied, offered itself, and we found the wind had not increased since morning, and that the Buss rode very well, as she was then circumstanced; our solicitude that nothing should be left in an exceptionable state, prevailed upon us to abide where we were, till the Edystone boat should return, when we might send her back for something proper to secure that link.—This over-precaution, as the wind was fair, and quite enough for us, cost us dear; for at three o'clock the wind and sea had so much increased, that it became unsafe to ride any longer by the buoy-chain; we therefore had no other alternative, but to launch the large floating buoy, and cast ourselves loose.

159. WE found the Buss go much better since her cleaning; yet the wind having by this time veered to the North of the East, which was but one point before our beam, and therefore in the common estimation of sailing fair for us; we found in stretching some length on our course, that we could not fetch Plymouth Sound; and an attempt to make a tack with our vessel, as we before had proved, would have been to no purpose. We therefore unanimously agreed to steer away before the wind for Fowey; and as it then blew a hard gale and was quite in our favour, we expected to reach our port before it was dark; which however we esteemed of the less consequence, as almost every one on board had been there before; and though we must expect the night to be dark, this being the day of the new moon, yet the headlands being bold, we concluded ourselves under no difficulty; insomuch, that for my own part having been up most of the former night, and a good deal fatigued in lending a hand to the forenoon's operations of this day, I went down to my cabin, and as it had been rainy, as well as stormy, I disencumbered myself of my wet clothes, intending to repose till I heard we were come to an anchor in Fowey Harbour.

The persons on board were, four seamen, HILL's company, Mr. JESSOP and myself; in all 18 hands. For the space of about three hours, I had the satisfaction to hear every thing going on well over head; and it was no small addition thereto, when I heard those on deck were altering their course, in order to run into the harbour: but suddenly an universal alarm and clamour arose, insomuch that I ran upon deck in my shirt, it then raining hard, and blowing quite a storm. It being very dark, the first thing I saw was the horrible appearance of Breakers, almost surrounding us; JOHN BOWDEN, one of the seamen, crying out, For God's sake heave hard at that rope, if you mean to save your lives. I immediately laid hold of the rope, at which he himself was hawling, as well as the other seamen, though he was also managing the helm; I not only hawled with all my strength, but calling to, and encouraging the workmen to do the same thing, in as little time as I have been describing our situation, the vessel's head was brought round, so that we no longer faced the breakers, which, from the darkness of the night, were almost the only objects we could see; the vessel was then heaved down by the stress of the wind, her gunnel to the water; but as we soon found she answered her helm, we concluded she was making way. It would require a pen of a different sort from mine, to describe the jeopardy of our present situation, while we were uncertain whether or not we should escape the rocks, on which the seas were breaking with a tremendous noise; we had been but a little time in this situation before our Jib was split to pieces, and to prevent our mainsail\* from suffering the same fate, we were obliged to lower its yard so much down the mast, that the sail did not present above half its surface to the wind; yet in this position the gunnel of the vessel was frequently dipped under

\* It has already been noticed that the Buss was Ketch rigged, that is, with a large square mainsail

water. Finding however our vessel to obey her helm, her head being South by the compass, the wind about E. N. E. we began to collect ourselves so far as to consider what was best to be done; some saying we had overshot our port; whilst others alledged that we were short of it: in this uncertainty it appeared to me, that our best chance was to stand out to sea, upon the point we then were; which though two points behind the beam (or large) we found was as near to the wind as, under the circumstances we were in, we could make way to advantage. We knew our vessel would float like a cork upon the water, till she was dashed to pieces upon the rocks. We could now see nothing of land on our lee side, yet the extreme darkness of the night, rendered still greater by the rain, and the confusion of the elements produced by the violence of the wind, made it uncertain whether we should be able to see the holdest shore, if of a dark colour, at the distance of 50 fathoms. Our danger therefore seemed to be that of falling upon the rocks that stretch away from Trewardreth Bay towards the Deadman\*. In this perilous uncertainty we continued nearly two hours, when having kept upon our point (S.) and meeting nothing, we concluded that we must have weathered Deadman's Point†; however we had still a violent stormy night to contend with, and having split our foresail also, we were now under our mainsail only, and though it was lowered as above described, yet even still we frequently dipped our gunnel in the water; several times the sea broke over us; yet our deck being flush fore and aft, and our vessel very buoyant, as before described, we shipped no water.

160. AT daylight on Tuesday the 23d we were out of sight of land, and having had the last of our yawls in tow all the night, in which time she had gradually filled by the spray of the sea (the storm being not at all abated) we found she greatly retarded our way, without any possibility of clearing her of water; we agreed therefore to cut her adrift; which indeed nothing but the apparent necessity of the thing could have induced us to do, as the yawl might be the means of saving our lives, though the Buss had been lost: but the necessity of this measure will appear, when it is considered, that in our present condition we might possibly do better than yield to the violence of the wind, which we found was driving us at a great rate towards the Bay of Biscay. On being freed from the incumbrance of the yawl, we determined to wear the vessel, and make the best point we could by standing in for the land; and the vessel's head was now pointed to N. W.—About noon we got sight of the coast on our weather side, which on a nearer approach we judged to be the Lizard; and could also discern land almost right ahead. By this time the storm began to abate; we therefore pursued our course, and before night perceived that the land we had before seen right ahead was the Land's End, and that we had been driving so much to the leeward of our course, that the westernmost point of land we could see was now upon our weather bow; we could therefore form no expectation, as the wind then stood, of fetching any port of Great Britain. Towards evening it became more moderate, and as we had on board a spare fore sail, a mizen, and a storm jib, we determined to set those sails, put the vessel about, and make one great effort to beat to windward, and flattered ourselves that with some assistance from the tide of Flood, we might be able to get into Mount's Bay.

We stood off the land at night, lying as close to the wind as we could make any way, our ship's head being about S. E. by E. wind at N. E. At two o'clock on Wednesday morning we again wore the vessel, and stood on for the land at N. W. by N. which we saw soon after it was daylight; we stood on this course till noon, when we found that our vessel had not altered her sailing properties; for that, so far from having gained any thing to Eastward, since the preceding day at the same hour, we had now got as much to the Westward of the Land's End, as we were yesterday of the Lizard: the Land's End bearing from us N. E. by N. distance by estimation eight leagues.—We were now fully convinced, that in this vessel, as the wind stood, we could not make any thing Eastward by sailing: we therefore lay to and sounded; and finding 40 fathoms water, bottom fine sand mixed with fragments of sea-shells, we let go an anchor, in order

\* A point of land East of the Lizard. See the general chart, No. 1.

† It has since appeared that we had not overshot our intended port, but had fallen short of it; having got into Lantipet Bay, to the Eastward of Fowey: had we really overshot our port, and got into Trewardreth Bay, as then apprehended, we could scarcely have escaped being wrecked on the rocky shore betwixt that and the Deadman.



that we might consider what to do.—The wind though now moderate but fresh, seemed invariably fixed to the N. E. we had therefore to consider, whether we should attempt to cross the Bay of Biscay, and get into some port of France, or Spain; lie where we were, as long as we could, in expectation of a shift of wind in our favour; or endeavour to get into some port in the islands of Scilly.—On mustering our hands, and our stores, we found we had not amongst us all above a week's provisions, at short allowance; and this seemed inadequate to the attempting to cross the Bay: for, if the wind should change, when we were almost over, we should be obliged, in obedience thereto, to return back again. In staying where we were, we might expend the whole of our provisions, and at last be left to make such shift as we could: we therefore were unanimously of opinion, that the last proposition, though attended with the most immediate apparent danger, from the rocks said every where to surround those islands, yet, as it would put the matter to the shortest issue, was the best to be adopted. We therefore resolved to shape our course for Scilly; but, having neither maps, charts, books, nor instruments on board, we could none of us tell (having never been there) what point to steer upon from where we were, so as with certainty to get within sight of the islands, especially should it come on foggy or hazy weather.

161. WHILE under this dilemma, we saw a sail to the East, steering directly to us; we therefore made a signal of distress, concluding, that if an enemy, the service we were upon would protect us; yet the state of anxiety we were then in was such, that we would have compounded for being carried to France rather than lie there with our present prospects.—The vessel bore down upon us, and proved to be the *White Hart* of Pool, bound for Guinea: we told them our situation, and service; but we having lost all our boats, and her's being stowed under deck, we could neither of us go on board the other; we learnt from her, however, what seemed very material to us to know, that our course for Scilly was W. N. W\*. We therefore determined to lie there till four o'clock the next morning; that by getting early under way, we might have it daylight by the time we could reach within sight of the islands; and that by having the day before us, we might have the better chance of making signals, and obtaining a pilot.—This evening the wind became more gentle, and at midnight it was a calm.

162. ON Thursday morning the 25th of November at two o'clock, the hands began to heave in our cable; for, anchoring in 40 fathoms, this was likely to take up some time: while it was doing, between three and four o'clock, a gentle breeze sprung up at N. N. W. The joy and satisfaction wherewith this inspired the whole company, tended greatly to expedite the getting up of our anchor; and by the time it was got to the Bows, the breeze was so much freshened at the same point, that we did not hesitate in abandoning our proposed visit to Scilly; and in lieu thereof directed the head of our vessel towards the Lizard.—The place where we anchored is referred to in the general map by the mark  $\text{S} 40$ , South-West of the Land's End. As the day came on, the wind still freshened at the same point; and we not only set our usual sails, but a topsail; and brought out every yard of canvas we could muster, as well as some of our blankets, which we contrived to set to some advantage as studding sails. Early in the day we passed the Lizard, and made our course good, so that at nine in the evening we were abreast of the Deadman. Soon after midnight we began to get sight of the Floating Light; at four on Friday morning the 26th, we once more espied our old acquaintance the *Ram Head*; and at six came to an anchor in Plymouth Sound; not without thankful hearts for this deliverance, and to the inexpressible joy and satisfaction of all our friends, who had concluded we had either been cast away or carried to France. And indeed such conclusions were not unreasonable; for the *Edystone* boat having been sent out on Wednesday (which was the first day she could look out to sea) and not finding us, returned with the melancholy tidings; and going out again on Thursday to make enquiry at the floating light, where they met with a very unsatisfactory account of us, our friends were not without great reason alarmed concerning us.

A few days after, the Buss was brought into Mill Bay, and laid upon the Beach, near the Jetty Head, that she might be in daily view of those employed in the work-yard.

\* This was indeed nearly the course by the true meridian, or rather N. W. by W. Had we therefore sailed upon a W. N. W. course, as directed us, by the compass, as we then understood it, we should probably have passed by the islands without ever seeing them.

163. HAVING now completed the relation as to the work of this season, I cannot in justice avoid paying that tribute to a deserving poor man that I think due to him.

I found my mind very forcibly struck with the distinguished activity and presence of mind of our seaman JOHN BOWDEN, upon the occasion of our missing the harbour of Fowey. I was fully convinced that had he not been on board, the Buss would certainly have gone ashore, most probably been dashed to pieces upon the rocks, and in the confusion and darkness of the night, several of us would in all probability have lost our lives: and therefore that the safety of the vessel, as well as ourselves, was owing to his expertness as a seaman. He had on all occasions shewn himself to be an active, sober, modest, obedient man; and in the light of a foremast seaman, he appeared to be quite a Genius; for, if any thing went wrong with the tackle on board, his readiness of thought, and invention, accompanied with an expeditiousness in the application of something for supplying defects, and remedying, if not preventing, disasters, was beyond any thing I had ever had the opportunity of observing amongst others of his class; and he was the only seaman in that station I have ever met with, who never swore an oath, drank a dram, or was seen disordered with liquor of any kind. Had I been an admiral, I could not have done less than signally have rewarded his services: but though my employers had generously left it to me to reward merit wherever I found it, I was obliged to be contented to do on this occasion what was properly in my own power: I therefore put him upon the same footing with WILLIAM SMART, who was master of the Edystone Boat, and had long been employed in the service of the Proprietors; paid him the difference of the wages, and emoluments, from the time of his entry; and further promised him the command of the first vessel that should be built in addition for our service: which boon I know not whether he had more satisfaction in receiving, or I in bestowing; but I was sure he could not be better satisfied with it, than I was convinced that he deserved it.

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### CHAP. III.

#### CONTAINING THE TRANSACTIONS OF THE WINTER OF 1756, AND OF THE FOLLOWING SPRING 1757, TO THE COMMENCEMENT OF THE OUTWORK OF THE ENSUING SEASON.

164. DURING this period, my operations were so numerous, diversified, and blended together, with respect to the time in which the several transactions were performed, that though I suppose a minute detail thereof was very interesting and satisfactory to the Proprietors at the time they were carried on, yet now such a particular relation would be unworthy of their attention, and much less that of the public: for which reason I shall only recount the leading or most interesting facts, without always regarding the precise days on which they were performed; unless it should appear proper in some instances so to do.

I have already mentioned, that our work-yard at Mill Bay was ready for the reception of stone, and the employment of stone-cutters: but though I found that Messrs. RICHARDSON and HILL were very well qualified for the Outwork, yet as they had been but little used to the working of Portland stone, upon the exact performance of which the Frame (if I may so call it) of our building depended; I was on that account induced to accept of the services of WILLIAM TYRRELL, who had been one of the masons concerned in the preparation of the stone at Portland for Westminster Bridge, and who, on the recommendation of Mr. RICHARDSON (on whom I found I could always rely,) offered himself as foreman over the stone-cutters, and to overlook the works of the yard.

165. THE general design and contrivance of our Work-Yard will appear by Plate No. 17, and the detail will be fully understood by the technical explanation of the plate; but to render it sufficiently intelligible for the present, I take this opportunity of explaining the principal properties thereof: and though the plan of a mason's work-yard may not appear to be a matter of much concern, or susceptible of much invention, yet in our particular case, the successful carrying on, and expediting of our works, depended more upon a convenient disposition of this, than can readily be imagined.

From the beginning I always laid it down as a fundamental maxim, that on account of the precariousness of weather to suit our purposes, (and without its being favourable, I think it has already sufficiently appeared, that nothing is to be done upon the Edystone) if we could save one Hour's work upon the Rock by that of a Week in our Work-yard, this would always prove a valuable purchase; and that therefore every thing ought to be done by way of preparation, which could tend to the putting our work together with expedition and certainty, in the ultimate fixing of it in its proper place; and for this purpose, it was necessary to make use of as large and heavy pieces of stone as, in such a situation as the Edystone, were likely to be capable of being managed without running too great a risk.

166. THE common run of modern buildings, even of the largest size, are composed of pieces in general not exceeding five or six hundred weight, except where columns, architraves, cornices, and other parts are to be formed that indispensably require large single pieces; because stones of this size and bulk are capable of being handled without the use of Tackles, or Purchases, unless where they are to be raised perpendicularly: yet it appeared to me, that this choice of general magnitude resulted only from the workmen's not having commonly attained all that expertness in the management of the mechanic Powers that they might have; in consequence of which, they avoid, wherever they can, the necessity of employing them. This arises not from the real nature of the thing, when properly understood; for a stone of a ton weight is, when hoisted by a proper tackle, and power of labourers, as soon and as easily set in its place, as one of a quarter of that weight; and in reality, needs much less hewing than is necessary for the preparation of four stones to fill up the same space; nor needs this reasoning stop at stones of a ton weight, but it might proceed even to as large sizes as are said to be found in the ruins of Balbec\*; if there were not inconveniences of other kinds to set on the opposite side of the question, as well as the want of quarries in this kingdom to produce stones of that magnitude.

167. THE size of the stones that could be used in the Edystone Lighthouse seemed limited by the practicability of landing them upon the rock: for as nothing but small vessels, that were easily manageable, could possibly deliver their cargoes alongside of the rock, with any reasonable prospect of safety; so no small vessels could deliver very large stones, because the sudden rising and falling of the vessels in the Gut amounted frequently to the difference of three or four feet, even in moderate weather, when it was very practicable for a vessel to lie there; so that in case, after a stone was raised from the floor of the vessel, her gunnel should take a swing, so as to hitch under the stone, one of such a magnitude as we are now supposing, on the vessel's rising, must infallibly sink her; and hence it appeared, that much of the safety in delivering the cargoes would depend upon having the single pieces not to exceed such weight, as could be expeditiously hoisted, and got out of the way of the vessel, by a moderate number of hands, and by such sort of tackles as could be removed from the rock to the store-vessel each tide: and on a full view of the whole matter, it appeared to me very practicable to land such pieces of stone upon the rock, as in general did not much exceed a ton weight; though occasionally particular pieces might amount to two tons†.

The general size of our building stones being thus determined upon at a ton weight, those would

\* There are three stones lying contiguous in the plain part of a wall, that from the measures amount together to upwards of 1,500 tons. See Wood's account of the ruins of Balbec. Descript. Plate 3d. Page 19.

† In the course of the building we have had instances of the boat's gunnel hitching under a stone in the tackle, and so as to unhook it: yet we fortunately never suffered any damage by losing the stones, as they always happened to fall from the gunnel into the boat.



have been far too heavy to be expeditiously transferred and managed, even in the work-yard, unless our machinery rendered that easy, which would otherwise be difficult, without too great an expence of labour: and as the moving and transferring the pieces of stone in the work-yard would be greatly increased in quantity, by the very mode of attaining a certainty in putting the work together upon the rock; this consideration made it still the more necessary, to be able to load upon a carriage, and move the different pieces from one part of the yard to the other, with as much facility (comparatively speaking) as if they had been so many bricks: for, that we might arrive at perfect certainty in putting the work ultimately together in its place upon the rock, it did not appear to be enough, that the stones should all be hewn as exactly as possible to moulds that fitted each other; but it was further necessary, that the stones in every course should be tried together in their real situation in respect to each other, and so exactly marked, that every stone, after the course was taken asunder, could be replaced in the identical position in which it lay upon the Platform, within the fortieth part of an inch.—Nor was this alone sufficient; for every course must not only be tried singly together upon the platform, and marked, but it must have the course next above it put upon it, and marked in the same manner, that every two contiguous courses might fit each other on the outside, and prevent an irregularity in the outline: and this indeed, in effect, amounted to the platforming of every course twice: so that, in this way of working, every stone must be no less than six times upon the carriage; 1st, When brought into the yard from the ship, to carry it to the place of deposition till wanted to be worked.—2ndly, When taken up and carried to the Shed to be worked.—3dly, After being wrought, to be returned to its place of deposition.—4thly, When taken up to be carried to the platform.—5thly, When finished on the platform to be returned to its place of deposition.—6thly, When taken up to be carried to the Jetty, to be loaded on board a vessel to go to sea.

It might at first sight appear superfluous, to try the courses together upon each other, as the under and upper sides of all the courses were planes: and, in case the work could have been put together upon the rock in the same way that common masonry generally is done, it would have been so: that is, if we could have begun our courses by setting the outside pieces first, then it would have been very practicable to have regulated the inside pieces thereto; but as our hope of expedition depended upon certainty in every part of our progress, this required us to be in a condition to resist a Storm at every Step: the outside stones therefore, unconnected with the inner ones, would have scarce any fastening besides their own weight, and would be subject to the most immediate and greatest shock of the sea; and after completing the outward circle, the inner space would be liable to become a receptacle for water: the necessity therefore of fixing the centre stone first, as least exposed to the stroke of the sea, and of having sure means of attaching all the rest to it, and to one another, rendered it indispensable that the whole of the two courses should be tried together; that if any defect appeared at the outside, by an accumulation of errors from the centre, it might be rectified upon the platform\*.

168. THE second week in December three vessels arrived from Portland, and their cargoes (amounting to about 120 tons) were landed, and stowed away in the yard with all possible facility; and on Monday the 13th, the masons first began to work the stone, under the inspection of Mr. TYRRELL, who that day entered as foreman of the yard.—I now found there was a likelihood of meeting with difficulties and delays in getting the moorstone; for having some time since given Course XI. to be roughed out by WALTER TRELEVEN, he came to Plymouth to inform me, that he had prepared the same, according to the moulds and my directions; but having engaged a

\* From a view of Plate No. 17, the reader will perceive that a vessel to be unloaded of stone being laid athwart the Jetty Head, a pair of Purchase Blocks being suspended from the top of the Shears, and the tackle fall (or running rope) carried to the small Capstand in the yard; the stones, being hoisted sufficiently high, can be delivered upon the four-wheel carriage that runs along the timber road, commonly called at the Collieries, where they are used, a Rail Road: and being landed upon the carriage, any stone can be delivered upon any of the Bankers in the line of the work-sheds on either side: or the carriage being turned a quarter round upon the Turnpike, or Turnrail at T, it can be carried along the road that goes up the middle of the yard, and be delivered upon any part of its area destined for their deposition; all the stones marked for the same course being deposited together; from which place they can be again taken up upon the carriage, run along the road, and be delivered upon any Banker in the line of sheds, or upon the Platform, and afterwards returned back to the same place of deposition, ready to be carried to sea in their proper order: the particular modes for the performance of which are explained in the description of this Plate, No. 17.—N. B. A Banker in a mason's yard is a square stone of a suitable size, made use of as a work-bench.

master of a vessel to bring it to Plymouth that spring tide, he had been disappointed by him, as he had been twice before by two others; all the three excusing themselves from their engagement, on account of the largeness of the stones, which they alledged were unmanageable, the larger sort of them weighing (to them the astonishing weight of) one Ton! And therefore, unless I could myself induce some person to fetch them, they must stay where they were. Finding nothing but difficulties and disappointments likely to arise from that quarter, I again hired Hancock's Sloop, and the next morning dispatched J. BOWDEN and three other seamen, with one of our smaller purchase tackles, in the sloop to Parr, with which the stones were got on board with all imaginable ease, and in three days deposited in our yard; and our moorstone hands began immediately to work upon them.

169. THE moorstone, though very hard with respect to its component parts, yet being of a friable nature, is extremely difficult to work to an Ariss (or sharp corner) or even to be preserved, when so wrought by great labour and patience, that is, with sharp tools, and small blows; it therefore soon appeared to me, that we should make very rough and coarse work of it, if the finishing of the pieces were left to the workmen of the country where produced; for, though carefully wrought there in their place, yet in loading and unloading from their carriages, and again putting on board, and unloading from the vessels, the Arisses would be very subject to damage. Therefore to have as much done in the country as possible, and to save weight in carriage, (leaving the finishing part to be done at home) rough moulds were sent for each size and species of stone, which were to be worked by them to a given parallel thickness, and with length and breadth enough, when so bedded, (as it is called) to be cut round all the sides to the true figure of the finishing mould: but they were to reduce them as near the size as they could safely do it by the hammer; and that they might not leave on unnecessary waste, they were to be paid no more for either stone or carriage, than what the mould measured upon the thickness given\*; and if they were wanting of substance sufficient to make the figure complete, it should be at our option to reject them when they came home.

According to this plan I soon after agreed with Mr. Box for 200 tons of moorstone; 100 tons of which were to be delivered by May-day next ensuing, and the remainder in the course of the following summer, to be laid down in our yard at the price of 20s. per ton†, clear of all charges, and 7d. per foot superficial for working the beds as before-mentioned. I also agreed with WALTER TRELEVEN for 40 tons of stone, conditioned as above, at the price of 25s. per ton, cubic measure of the moulds, and 4d. per foot superficial for working the beds, to be delivered by May-day at Parr; we undertaking the water-carriage.

There was some difference in the price, upon the whole, between the two contractors; but this was the least material part of the consideration: however as the terms with Mr. Box were not only the lowest, but his stone was less friable and better coloured, and would give us no trouble in getting home, it may reasonably be asked, why I did not get the whole quantity wanted from Mr. Box? The reason was, 100 tons were not sufficient for the service of the approaching season, and he could not undertake for more in due time. I might indeed have made 100 tons suffice, could I have been sure of its delivery; but as accidents and disappointments might happen, as well to Mr. Box as to Mr. TRELEVEN, it appeared to me, that the way to be safe was, to order a quantity from both; besides, I found, that had I not before given an order to WALTER TRELEVEN, I had not had the offer upon so low terms from Mr. Box; who now plainly saw, that if he did not agree with me, the order for the whole would go to his rival.

170. AS soon as the works of the yard commenced, I constantly visited them twice a day; and as I laid down all the lines myself upon the mould-room floor, I was not without a regular series of daily business.—It was judged necessary, for the service of the next season in carrying out our stone and materials, immediately to set about the building of additional vessels: the making of proper designs therefore for those vessels, and the surveying the construction thereof, with oc-

\* There was to be no deduction from the contractor, on account of the contracted waists of the moulds.

† The ton was to measure 14 cubic feet.

casual duty in the yard, furnished a fixed employment also to Mr. JESSOP.—It has been already observed, that it was wholly impracticable to carry vessels of any considerable burthen into the Gut to deliver their cargoes; it therefore appeared, that our service would be best performed by multiplying small vessels, of such a size as to be tractable when lying to unload therein, and which could readily be hauled in and out by a small number of hands. It appeared also impracticable to make use of vessels decked over the hold, where the stone was to lie; for any thing being in the way of their rising would be subject to hitch upon the stone, so as to occasion the breakage of the tackle, and the fall of the stone; so that in this view, they would require particular dimensions and constructions.

It appeared, however, that we might make use of vessels somewhat larger than the Edystone boat, which was about 12 tons; but we judged 16, or at the utmost 18 tons, was as large a vessel as could well be managed in the Gut. Mr. JESSOP judiciously advised their being built unusually bold in their Bows, and to have a sufficiency of height, or depth, to render them very floaty and lively in a rough hollow sea; though by this mode of construction they might not be so speedy sailers. It also appeared, that as there could be no taking in of ballast, when they had delivered their cargo at the Edystone, they must necessarily always be in sailing trim; and consequently, that the necessary tonnage of the ballast must be so much to be subtracted from the whole burthen of the vessels, the remainder only being the tonnage of materials that could be put on board them. But this was not to be the only deduction from their whole burthen; for we judged it would much contribute to the general safety, not to load them more than within one-fourth or one-fifth of their full capacity, which would not only render them buoyant upon the water, but be a sufficient allowance for an occasional addition by carrying other building materials, as also the companies.

To form some estimate therefore of what we should want; suppose from the whole burthen of 18 tons, we deduct four tons for ballast, and allow each vessel to be four tons underloaded, then an 18 ton vessel would carry a cargo of ten tons. How many of these vessels we might probably want, was determined as follows:—We could not expect in the approaching year to get the building higher than the completion of the entire solid; and as the plan of every part thereof was already fixed, we could easily determine, that the tonnage of this part of the work would be about 450 tons. Now supposing our working season to be, the months of June, July, August, and September, and that during this season, we could at an average operate with full effect for two days in the week; then in this space we might expect 35 working days, and this would amount to about 13 tons that should be carried out per day.—The Edystone boat's burthen being about 12 tons; admit her to carry three tons of ballast, and to be three tons light, then her cargo would be six tons, which, with a new boat's cargo of ten tons, would make 16 tons, that is, three tons more than the quantity required: but as things of this hazardous nature seldom come up to calculation; as here is too little to make up deficiencies, or possibly the loss of a boat, we judged it requisite, in order to guard against accidents, that two new boats of 18 tons each, should be built.

171. IN regard to our Yawls, having lost them all, the experience of the last season taught us what we should want, and what best answered our service; and having now not only the opportunity, but time also, we provided ourselves accordingly. We much regretted the loss of our original large yawl, which was of Mr. JESSOP's providing, while I was last in London; as it completely answered the service for which it was built: but being too large, and too heavy, to get upon the deck of the Buss after every tide's work, we were obliged to let it lie at her stern, and in the hard gale of the 13th of October, it gradually filled by the broken seas driving into it; and there being at that time far too much sea to haul it up and clear it of water, it became by degrees heavier and heavier, and at last broke the Painter\*, and went adrift as before-mentioned.—The yawl that we lost in the last storm, when we were driven out of the Channel, was one procured from Deal, which place is famous for the building of this kind of boats, both for lightness and ability to bear the sea: this boat, when not in use, was commonly hauled upon the deck of the Buss, but as in our passage from the Edystone to Fovey, we were almost right before the

\* The name given to the rope which is fastened to the Stem of a boat, and by which it is either detained or hauled in.



wind, the getting her on deck, while we were thus sailing, was thought unnecessary, as we should immediately have wanted her in the harbour : and afterwards it became impracticable.

As there was now upon sale a vessel and her equipments, in different lots, we purchased her long boat, being a stout broad boat, much of the size and model of the great yawl we had lost, and which would answer for her occasional service ; we called her the Sea Horse yawl from the name of the ship to which she had belonged. However, as we saw very plainly that we should be frequently losing our boats on the out-service, unless we could take them all on board the Buss, we determined to build two light yawls, of such size and construction, as that both might be stowed upon the deck of the Buss at once, and also to build them at home ; because, though for want of time, Mr. JESSOP had ordered the former light yawl from Deal, and sent the builders there the dimensions and sort of vessel ; yet they confiding that their experience in this branch needed no directions from any one, sent us a boat much about our size, and sufficiently light, but considerably narrower in proportion to her length, as well as sharper both before and aft : which though perhaps better adapted for rowing in moderately rough water (and which doubtless would answer very well at Deal) yet was not so well adapted to the hollow distracted seas that are frequently encountered among the Edystone Rocks, as we evidently found the bold full-breasted boats to be. As all the vessels built by Mr. JESSOP's directions fully and completely answered their intentions in our service, I am sorry that I have it not in my power, for the sake of those, who may happen to have a work to perform in rough Seas, to give the delineations of them ; for though the designs were regularly made out by Mr. JESSOP, yet by being worn out in the builders hands whilst they were in use, they were not preserved ; I happen however to have by me the original draught for one of the smaller yawls that Mr. JESSOP produced to me for my approbation, and Plate No. 16, contains a tracing thereof from his own drawing, which will indeed serve for every size of Yawl, by altering the scale ; but our large boats for carrying out the stone, though much of the same kind of mould, were considerably deeper in proportion. The figure of the boat represented as lying in the Gut delivering her cargo, Plate No. 14, though only sketched from memory, yet may serve to give some idea of what they were, especially if attention be given to the real design of the yawl, Plate No. 16. The principle of all our vessels, as far as they differed from common ones, was, that they were considerably broader in proportion to their length, and remarkably full in their bows ; which, though not adapted to make way swiftly through smooth water, yet enabled them to float much more lively upon the surface, when a sharper vessel would almost bury itself in the water ; they were therefore not only safer, but even made better Way in a rough sea.—Accordingly, one of the large boats of 18 tons, and a light yawl were immediately put in hand.

172. IN this respite from sea operations, I seriously began to consider the great importance that it was likely to be of to our work, to have a Cement the most perfect that was possible, to resist the extreme violence of the sea. And on a consideration of this matter, it appeared, that nothing of the resinous, or oily kind, could have any place in our work, as it would require the surface to be dry, to enable it to make a complete adhesion ; whereas the getting any thing completely dry, was one of our greatest difficulties. It seemed therefore that nothing in the way of Cement would answer our end, but what would adhere to a moist surface, and become hard, without ever becoming completely dry.

173. I BEGAN now to foresee that before I could have a complete sample produced of every part of the work, that might be wanted for the operations of next season, it would be pretty far advanced in the spring ; and as I proposed beginning the outwork as early in the season as possible, I determined to winter at Plymouth (without returning to my residence in London, as I had before intended) though to the detriment of my own private concerns ; laying every consideration aside in favour of the Edystone. I therefore resolved to take every opportunity in the evenings and intervals of my attendance on the work-yard, mould-room, &c. to go through a complete set of experiments on Cements, so far as it concerned the subject I had in hand : for I plainly saw from the manner of working the moorstone, already described, that not only much of the beauty and neatness of the work, but its real solidity too, would depend upon getting a Cement

that would, in despite of water almost continually driven against it with every degree of violence, become of so firm a consistence in itself, and adhesion to the stone, that it should lie fair and flush in the joints, and so as to compose one even regular surface with the stone; and without needing Hoops of Iron or Copper to surround the horizontal joints, as seems to have been the expedient of Mr. WINSTANLEY. I was so fortunate as to succeed in this part of the business entirely to my satisfaction; and perhaps in a degree unknown before: and having made much use since of the experience which I then acquired; having had frequent occasions and opportunities of communicating it to others; and having been asked many questions concerning it; I trust that my reader will forgive me, if I am diffuse enough to enter into a full explanation of the subject, so far as I know it. I mean not however to tire him with recording all the particular experiments, as this would be almost endless, they having been pursued through the whole of this winter; but only to state the principal scope and design of them, with the results: nor do I propose to enter into a chemical disquisition upon them, which I leave to the learned in that science. But as what I have to say on this subject will carry me to some length, I shall reserve it to a distinct chapter, in order to keep the matter together.

174. EARLY this spring I thought it expedient to make a journey to the West, not only to survey the moorstone works that were then going on, but to acquaint myself with Mount's Bay, in case we should have a future occasion to take refuge there.—I must however premise, that on the 25th of January, in returning from Mill Bay at five o'clock in the evening, I observed four flashes of lightning towards the West, within the space of six or seven minutes, but heard no noise of thunder. A few days after, I was informed, that the same evening the lightning had shattered the church of Lostwithiel, in a very surprising manner: and though from the many relations I had read, I could not doubt, but that the effects of lightning were very great; yet as this was the first opportunity that had occurred to me of seeing them with my own eyes, I was very solicitous not to lose the opportunity. I therefore on this journey called to visit this church, not only as an object of curiosity, but as a matter very interesting to my own work; and I communicated a particular account of these effects to the ROYAL SOCIETY, which as it stands recorded in the 50th volume of the Philosophical Transactions, for the year 1757, page 198, I shall take no further notice of here, than as it immediately applies to the subject I am upon.

The steeple of the church of Lostwithiel before this accident was 113 feet high, whereof the lower part was a square tower of 49 feet, finished above with an elegant Gothic octagon lantern, 12 feet high, and above it a stone spire of 52 feet, of which a portion of 20 feet of the upper part was entirely burst, and dispersed in all directions; and some of the stones that composed it were found at the distance of 200 yards.—The masonry, as is usual in ancient and well-built spires, was very light, the stones composing the shell of it being no more than seven inches thick; so that the single stones of it could not in general exceed one hundred weight: yet as they were all curiously joined together at the ends, mortoise and tenon fashion, and appeared to have been exceedingly well cemented together, nothing, as it should seem, but a great power of some elastic vapour, similar to the sudden explosion of a considerable quantity of gunpowder, could have burst and dispersed the materials of the spire in the manner it had done: for besides the part entirely destroyed, to six feet further down, one half of the shell was thrown down, and the other half left standing, in so perilous a state, that it was judged necessary to take it down; and on doing this, the work was found so disjointed and shattered, that it was thought necessary to take down six feet more. It was in this situation when I viewed it, the beginning of March; and I found that the whole of the spire left standing, as well as the lantern, was greatly cracked, and damaged. Many other circumstances occurred which shewed the effects of an elastic vapour, that wanted to get at liberty by expansion, somewhat similar in its most obvious effects to that of gunpowder; and under this idea, I might have been tempted to suppose, that had the shell of the spire been rendered stronger by cramping the stones together, as well as tenoning the ends, it might have sustained the elastic pressure outwards, without being torn to pieces: but there were some attending circumstances which convinced me, that the action had not been altogether in the way of an included elastic vapour, endeavouring to expand itself; upon which principle, the weakest part would have given way, and have afforded an opening to the vapour: for, at the bottom of

the steeple, at the level of the ground, an hole had been pierced entirely through the wall, and through an opposite buttress, whose compound thickness amounted to eight feet; whereas at the distance of a foot sideways it might have got through by piercing the wall alone, which was not more than five feet thick.—This circumstance, beyond all the devastation that had been made, both in the steeple and the body of the church, convinced me, that there could be no certainty of making any wall so strong as to withstand the action of Lightning; and consequently that no security against the effects of it, that human sagacity had either discovered, or could suggest, ought to be omitted in any building of consequence. Therefore, however strongly I was disposed, before I saw this example, to adopt the proposition of Dr. (then Mr.) FRANKLIN, for the preservation of buildings from the effects of lightning by means of a Conductor (which had not at that time become popular) this instance applied itself so closely to my feelings, that I determined to put his method in practice in my proposed building, in the best manner I was able: and the particular mode in which this was done, will be fully explained when we come to that period of the building.

175. DURING the time the experiments on Cement were making, and the works of the yard proceeding vigorously, I was very desirous to find an opportunity of going upon the rock to complete our moulds for the foundation courses; but it was very seldom at that time of the year that the weather, even in appearance, was promising. However, Wednesday January the 12th, there having been some days of frost, with moderate breezes, this morning the water in Plymouth Sound was very smooth, and I went on board the Edystone boat with Mr. JESSOP and the mould-maker, the Sea-Horse yawl attending. All continued promising till we got out of the Sound, but without the Ran Head we met with a swell from the South, which increased as we came nearer the Edystone, so that when we came there, we found the sea beating over it with great violence at low water: we ran within twice our boat's length of it, on the West side, to have a view of the work, in which we could not perceive any injury from the late storms, nor change, except that the new surface was of the same colour as the old; being all grown over with dark coloured green sea-weed. We also ran alongside our buoy upon the moorings, and had the great satisfaction to find it floating, and in good order.

We made several expeditions of the same nature in the course of the spring, and with no better success; so that it was not till the 23d of April that we got a landing. We then went out in our first new boat, which was launched on the 22d of March, and was called the *Weston*, JOHN BOWDEN, master. There being little wind, we were obliged to row almost all the way. Between twelve and one, when we were now about a league from the rock, it became calm; and as we were not soon likely to get out with the great boat, we betook ourselves to the *Sea-Horse* yawl which attended us, and in an hour landed, and got a tide's work of four hours; in which time having marked a durable middle line upon the rock, we got the moulds completed for Courses I. II. and VI. except that a right line was wanted to be drawn upon them, to enable us to join them together again on shore, in the same position exactly in which they lay upon the rock; and for this particular use a ruler had been provided, which being too long to carry in the yawl, was left on board the *Weston*, to be brought forward by her: but as she did not arrive at the moorings till we were obliged to quit the rock, this was a sensible disappointment; however it did not prevent us from completing for use the courses we had framed: for, by stretching a piece of pack-thread over the moulds, we were enabled to bore two small holes in every piece; so that when the parts of the moulds were laid together in contact upon a level floor, and those holes brought into a right line, they would then be in the same position as they were upon the rock.—As it remained calm, we determined to stay in the *Weston* all night, but, on examination, finding the carpenter had neglected to bring off an additional paper of nails that he was expressly ordered to bring, and reminded of, this trifling incident, however small in itself, was yet likely to put a stop to our farther proceedings; for not being able to form any expedient to do without the nails, the carpenter and three seamen were dispatched in the yawl for Plymouth to bring out this necessary article. The weather continued calm all the night, but in the morning it began to blow fresh at S. which brought on a swell; and not only prevented us from landing, but obliged us to return to Plymouth.—Upon the 30th, we got a very good landing in the yawl, and had the



good fortune to complete the whole of the moulds that were wanting, just in time to quit the rock when the wind and sea would very soon afterwards have obliged us to do so.

176. THE accomplishment of these moulds, (an object much desired ever since the conclusion of the last year's work) having been thus happily effected, after much delay, disappointment, and danger; the next thing was to procure a room, upon the floor of which we could lay them together, and, by laying down chalk lines, form the rest of the pieces that were wanted to make up each course, to which they formed, as it were, the Roots. This requiring a larger room than any we had at our command, I applied to the Mayor of Plymouth for the use of the floor of the Guildhall: and I am very sure the present magistrates will blush for their predecessor, when they are told that his Worship had so little feeling, or attention to the public service, that I was absolutely refused, on pretence that the chalk lines would spoil the floor. I afterwards applied for the Assembly Room, but there I succeeded no better. These unexpected rubs were not however insuperable; for by removing a partition between two rooms, which were the garrets of our cooper, I got a floor large enough to hold each course at twice; and to this, though attended with a considerable addition of trouble, yet as it would only occur in the third, fourth, fifth, and sixth courses, I determined to submit, rather than subject myself to any more Denials.

177. IN considering at leisure the various impediments to which our work was liable, it behoved us to endeavour to remove every thing of that sort possible. Though our predecessors, to prevent annoyance from an enemy, had a vessel of war upon the station to protect the workmen, yet the generous behaviour of the French King on a former occasion, (mentioned § 57,) gave us assurance that we should have nothing to fear from the enemies of the state. But yet we had experienced, during the course of the last season, a good deal of hindrance and interruption from our Friends; for our boats were frequently stopped and boarded by the men of war's cutters, to impress the seamen; and notwithstanding they were furnished with Admiralty protections, yet there occurred some instances of the officers being so indiscreet as to pay no regard either to the protections or the service they were upon. And though our men were always released with politeness, when the matter was represented to the Commander in Chief, yet all this produced delays and hindrances incompatible with the urgency of our business. And as it plainly appeared, that nobody would molest us, provided it could be made clearly to appear, without collusion, that our men were really and *bonâ fide* employed in the Edystone service, it occurred to me, that if a large figure of the Lighthouse was painted upon the mainsail of our boats, it would be an evident mark of distinction at a distance, and prevent their being stopped. But yet, that after all, the seamen, when on shore, would still be liable to be detained, when absent from their boats. To prevent this, I considered, that if I had a stamp, which could not readily be counterfeited, with which one might at pleasure stamp a piece of silver, each man employed by us might thus be furnished with an evident token in his pocket of the service to which he belonged. This idea having been communicated to Mr. WESTON, he soon got a sufficient number of silver medals made for the purpose, of which Fig. 7, Plate No. 18, is the representation: and after the distribution of these, and the painting of the sails, we never had any further interruption.

178. A HINDRANCE of another kind however arose; for about the middle of February, we had advice from Mr. TUCKER, that the frequent appearance of French privateers had intimidated the masters of the Portland vessels so much, that they were afraid to stir out: and this gave me the more solicitude, as all the stone we had received from Portland was then nearly worked up. On communicating this, Mr. WESTON immediately applied to the Lords of the ADMIRALTY, who dispatched an order to the commander in chief at Portsmouth, to send a convoy upon notice from Mr. TUCKER, of any vessel being ready to sail that was freighted with stone for the Edystone. However, before any convoy was sent, two vessels thought good to run it; and arrived with a fresh supply of stone from Portland the 8th of March, and carried back to Portland the moulds for all the stone that could possibly be wanted in the course of the ensuing Summer.

179. AS we had been for several days without any unwrought stone in the yard; the masons

were employed in detaching sufficient pieces from the neighbouring marble rocks, and forming out of them cubes of one foot each side, for inlaying between the different courses; as will be more particularly described hereafter in its proper place: and the labouring tinner were employed in drilling a couple of holes through the outward end of every single stone; by which they were intended to be trenailed down to the course below. For, though I could not easily conceive, when each block was fixed in its place, by oak wedges in the dovetail space cut out of the rock, or furnished by the work already fixed, that any thing could move it; yet, considering the unmeasured violence of the sea, I determined to omit nothing that could tend to keep the whole firm together, while the cement was fresh and unhardened; as that seemed the best way to prevent derangements and disappointments, while things were going on: and soon after, we purchased 300 trenails, of the best quality, and the same size that I understood was used in building the first rate men of war; being  $2\frac{1}{4}$  feet long, and two inches square, in the rough.

180. IN carrying on a work of this sort, I have always found it more difficult to manage the workmen employed, than to controul the elements. High wages and encouragements may have the effect of inducing men, in cases where they cannot be compelled, to enter into such services, which no other kind of persuasion would be able to accomplish.—This mode, however, by no means teaches them Submission and Obedience; on the contrary, it leads them to suppose that every success, in the operations they have been concerned in, is owing to their own personal merit and address; and that, had they not been employed, the thing could not have been done by any other persons: of this I had several examples in the course of the outworks of the last season; having discovered a strong tendency to Mutiny and Combination.—WILLIAM HILL, though as a foreman he received one shilling per hour extra pay, and had in one week of the preceding season intitled himself to the receipt of near five Guineas, (including his constant wages,) yet this by no means increased his gratitude for being taken into the employ, or his attachment to the service. In short, having found him irregular and disorderly, and privately a sower of discord among the workmen; and having always in such cases experienced it to be the most effectual method to lay the axe to the root of the tree; I discharged him the service for disobedience of Orders, as an example to less offenders.—This transaction being upon a Saturday, on Monday following, HILL came into the yard to fetch away his tools, and claimed the fulfilling of their promise of all those who had worked with him upon the rock; which was, “that if he should be discharged they would all follow him.” Upon this I instantly called them together, and desired that whoever had any dependance upon, or attachment to, WILLIAM HILL, would take away his tools and depart the yard immediately; which one of the moorstone masons did, all the rest prudently chusing to stay where they were.

181. THIS transaction gave an opening to rectify what I had plainly perceived to be an evil to the service of the Outwork; that is, that the Premiums with respect to the inferior workmen were not only too near that of the foremen, but in reality higher than necessary to countervail the risk, in their own Opinions: and indeed every encouragement more than that tended only, as we have seen, to make the men disorderly and untractable: wherefore after consideration, the following Saturday I called together in the yard all the workmen that served upon the rock during the last season, and represented to them, that in proportion as the house was raised, the number of hours they would have opportunity of working thereon would increase, and the work become easier and less hazardous; and that therefore they ought not to expect the same premium by the hour, the ensuing year, that they had had the last year; and that in consequence I intended to settle such a price at the beginning of the work of this season, as I proposed to hold to till we could make a lodgement thereon; for then, they would be able to make regular days works; and that the price I should now fix would be six-pence per hour for the masons and carpenter, and four-pence per hour for the tinner; their weekly wages to be the same as last year: and under these conditions every individual might take his choice, either of working constantly in the yard, or of going off to the rock by rotation every other week. Whereupon every one without hesitation declared his readiness to serve upon the rock, upon the terms offered: an event which gave me particular satisfaction, as it would not only be a considerable saving to the proprietors,

but the work itself would be quite as well and expeditiously done. And, though it is not an easy matter to reduce emoluments, with the Consent of parties; yet I have always found amongst mechanical artificers, as I suppose it is with other denominations of men; that firmness, justice, equality, and a fair alternative, will always carry the point.

182. IN the month of May I received a letter from Mr. TUCKER, importing that in consequence of the ADMIRALTY's order, he had some time ago applied to the Commanding Officer of the Fleet at Portsmouth, to have a convoy for the Edystone materials to Plymouth; that he had regularly got an answer from the commanding officer, that a convoy should be sent; but that no convoy had come. This was repeated, and answers regularly received; but the fact was, that no convoy did ever attend this duty: so that the favourable sentiments which the Lords of the ADMIRALTY, and their principal commander had of the importance of our work were yet defeated; as it happened not to appear in that light to those who were appointed to the service: so that we remained equally unserved, as if we had never had any order of assistance. Doubtless on proper representation, this neglect would have been duly adverted to; but as the delays, before they amounted to a matter of complaint, had been such, as to oblige us to run all risks; and nothing in reality had happened adverse; we thought it unnecessary to trouble the Admiralty for a kind of redress that could then no ways conduce to the re-erection of the Edystone Lighthouse.

183. IN the course of the month of May we received from London five fathoms of additional main chain proposed to be added to the six fathoms that already acted as a bridle, which, as it would make us eleven fathoms of bridle chain, and this was more than half the depth of the water at the place of our mooring, would prevent the necessity of lifting so considerable a part of the ground chains from the bottom in mooring or unmooring, and thereby prevent a loss of time, that might in effect prove considerable: for in many cases we had seen, that the want of an hour, to the accomplishment of such points of our business, as depended upon winds and seas might prove a delay of weeks, which might ultimately occasion the loss of a season in the finishing of the building.—These necessary preparations having been made, and a quantity of Plaster received, ready prepared for use in London, and close rammed into five casks, to prevent the bad effects of the air upon it; we were now ready for commencing the operations upon the rock as soon as the season would give us room to suppose we were likely to have success in carrying them on: but previously to my relation of the works of the approaching season, I shall now perform my promise of giving an account of my experiments and observations respecting the Cement we used, which was referred to a separate chapter.

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#### CHAP. IV.

##### CONTAINING EXPERIMENTS, TO ASCERTAIN A COMPLETE COMPOSITION FOR WATER CEMENTS; WITH THEIR RESULTS.

184. ON this subject, I was already apprized that two measures of quenched or slaked lime, in the dry powder, mixed with one measure of Dutch Tarras, and both very well beat together to the consistence of a paste, using as little water as possible, was the common composition, generally used in the construction of the best water-works both in stone and brick; and which, after being once set\*, would afterwards become hard, without ever being completely dry; nay, that it would in time grow hard, even under water. This therefore seemed to be the kind of cement adapted to our use; and what I had yet to learn, was, the best materials, and mode of treating

\* This is the term used in the application of calcareous mortar, which denotes its first step, or degree of hardening; but in this state, though it has lost its ductility, it is a very friable substance.



and using them. I was ignorant at this time, whether there would be any difference in the firmness of the mortar, on account of the lime being made from different kinds of lime-stone, provided the proportion of the ingredients was suitable. I found it indeed commonly asserted by Masons, that the harder or stronger the Lime-stone was, the stronger would be the Lime; but whether this maxim chiefly regarded the usual composition of lime and sand in common buildings (with which they were chiefly acquainted) or whether it held good also in Tarras Mortar, did not appear.—It was also generally agreed by masons, that mortar, if mixed up with salt water, would never harden in so great a degree, as the same kind of composition would do if made with fresh water.—I could readily conceive, that if mortar was mixed with salt-water, and used for the plastering, or even the walling, of a dwelling-house, the wall so built would never become so perfectly dry, but that when the atmosphere was in a humid state, the sea salts, by this means conveyed into the composition of the mortar, would attract the moisture of the air, and render the wall visibly and palpably moist: Nay I have been told, that if a house be covered with plaster which has sea sand in its composition, though it is mixed up with fresh water, or even if sea sand is made use of in the joints of the walls, it will shew its affection to moisture in very damp weather, and the plaster over those joints will become evidently discoloured. But as it appeared to me, that in the case of Tarras mortar, drying and hardening were distinct properties, not evidently dependant on each other; it might be, that though Tarras mortar made up with salt-water, might equally discover its sensibility of moisture, if used for the same purpose, as common mortar made up with sand only; yet this circumstance might not impair its hardness, or firmness of Adhesion, where perfect dryness was not wanted; consequently it would be no injury, in the subject of Water Building: and as the necessity of carrying out, or not, from the land all the water we should have occasion for in this building, was a matter of moment, the full investigation of this question became very material.

185. THE first object of enquiry, as I had heard much complaint from the workmen, of limes not being well burnt, was, whether good or bad burning affected the Quality, or the Quantity of the lime produced from a given quantity of stone, or both? Therefore, in my first essays, I did this part of the business myself; the result as it then appeared to me, was, that if the stone was not exposed to a certain degree and duration of fire, according to its original hardness and compactness, it remained stone, without becoming lime; or was converted into lime to a certain depth from the outside only, the parts near the centre remaining stone: the distinction between Lime and Lime-stone being (so far as I have had occasion to enquire into it) that lime-stone, after it has been exposed to a sufficient degree of fire, will, on throwing water upon it when in large heaps, or plunging a single lump into water, and quickly drawing it out again, become hot, smoke, and swell so as to be resolved into a dry impalpable powder, in which state it is called slaked Lime; I suppose, to distinguish it from that soft, moist, earthy substance, which it becomes on such a further addition of water, as must be used to prepare it for making mortar. Now if the lime-stone is imperfectly burnt, it only in part falls into slaked lime; the residue not being capable of being reduced to that kind of mealy powder, which, with a further addition of water, and a little beating, becomes a tough kind of paste; and which is capable of firmly uniting into one mass, with any kind of hard, sandy, or gritty matter, that may be introduced as a mixture with it, in the composition of mortar for masonry: whereas, the part that will not so fall down, instead of a soft pasty substance, becomes in general rather more rigid and hard by the addition of water.

I therefore tried a quantity of powder-lime that had fallen from a stone imperfectly burnt, and an equal quantity of lime from one that was thoroughly burnt; and having in other respects treated them in the same manner, both with salt water and fresh, I found the former to work somewhat more harsh, but that ultimately there was no material difference in the quality of the mortar: and from hence I formed this conclusion, that the complaints of workmen on this head were rather founded upon the great waste, and small produce, from imperfectly burnt lime, than from a real difference in the quality of what is produced. It is however to be noted, that I took none of the slaked lime, that was produced from the imperfectly burnt stone, but what would pass the finest sieve; because I conceived, that a degree of burning may be so much in the con-

finer of what is enough, and what is not enough, as that the stone may fall to such a degree of fineness as to pass a coarser sieve, and yet not fall to that impalpable powder necessary to form a complete paste. For though, when passed through a coarser sieve, there may be enough of the finer parts to form a paste, yet in this way a comparative experiment would be rendered inconclusive, because the small parts of unburnt stone must be considered as so much admixture of Sand, or gritty matter, and this at least alters the intended proportion between the quick-lime and the gross matter. The result of this experiment however, though it shews that the use of imperfectly burnt lime is not only wasteful, but in every sense of it ineligible, when applied to a work in large; yet it sufficiently secured me in the course of my experiments, from any doubts that might be formed, of the results of such as were made with slaked lime, which was neither of my own burning, nor of my own quenching; because it was always easy to get enough passed through the finest sieve, for the purpose of an experiment, though it might prove impracticable to get enough so passed to answer the demands of a real building\*.

186. BEFORE I proceed any further, it will be necessary to explain the mode in which I compounded, and made up my mortar for trials. I took as much of the ingredients, as all together would ultimately form a ball of about two inches diameter.—This ball, lying upon a plate till it was set and would not yield to the pressure of the fingers, was then put into a flat pot filled with water, so as to be covered by the water; and what happened to the ball in this state, was the criterion by which I judged of the validity of the composition for our purposes.—The measure I used was a common small chip box, taking as many measures from each ingredient, as I meant to try.—I constantly put down the lime upon the flat bottom of a common pewter plate, and with as much water as would sufficiently wet it, worked it upon the plate, with a broad pointed knife, till it was become a tough but a pretty soft paste. I afterwards added the quantity I intended of tarra, or other gross matter, gradually; working it after each addition till it was become tough; and in this way, adding the gross matter at three or four different times, I was generally enabled to get in the whole quantity, without any addition of water, more than had been necessary to bring the lime only at first to a proper consistence. The whole was thus worked till it acquired a tough and stiff ductility; but if it happened, by the addition of too much water, to become too soft, I let it stand till it began to set, which might be quickened by putting it a few minutes upon a dry stone, or brick, and when it was a little hardened by partially setting, I worked it till it was brought to a stiff paste; the whole of which operation took up generally above a quarter, and sometimes near half an hour, to make a single ball.

187. IN making up balls of mortar in this way, however well they were worked, if made up of no other ingredients but common lime and sand; though this might be denominated excellent mortar for the common purposes of building, yet upon being immersed in water, I found none of them which would not dissolve; and therefore I judged such sort of mortar, however hard it might become by being gradually dried, was totally unfit for our work.—Balls even of the common composition of Tarras mortar (two parts slaked lime to one of tarra) I found would not always stand this test: but balls made up with equal measures of lime and tarra would in general stand it. This degree of information, though in itself very material, was soon attained; but as many points seemed to want investigation, I regularly proceeded to determine the following questions.

Question 1st. What difference in the effect results from lime burnt from stones of different qualities, in point of hardness?

Chalk lime is generally considered by workmen as the weakest of all; and it is accounted for

\* These were my conclusions then; about which time the learned Dr. BLACK discovered that lime-stone by burning would lose nearly  $\frac{1}{10}$  of its weight, by the expulsion of fixed Air, which is driven off by the force of fire. And since him, Dr. HIGGINS has discovered, that a less quantity of the Gas is driven off by a less force of fire, however long it is continued; and that when completely driven off, that is in the proportion above, or nearly so, the lime then falls the most freely in quenching, or slaking, and to the most impalpable powder: and he concludes from a series of experiments, that lime so burnt makes the best and hardest composition of mortar: but how far these conclusions will apply to mortar for water building, which has not the advantage of induration by drying, (as those specimens had which were the subject of the Doctor's experiments) it is still out of my power to determine.—Higgins on Calcareous Cements, § 2 and 4.

in general, by its being burnt from one of the softest of all limestones.—The marble rocks near Plymouth are of so hard a nature, that the stone obtained from them to be burnt to lime (and which is the common lime of that country) is, by far the greater part of it, blasted off with gunpowder. From observations of the buildings about Plymouth that had been constructed with this lime, at different periods of time, it appeared to me to be very nearly of the same nature with chalk lime; not only being of the brightest white, but of the same weak crumbly nature. I therefore made a couple of balls of tarras mortar of each sort of lime in the above stated proportions of two to one; and also equal parts; and the result of several trials of the same kind was, that there was no apparent difference in the strength thereof for the purpose of water building\*.—Hence it appeared, as the effect of two limes was the same, from one of the strongest and one of the weakest species of limestone; that the strength of the lime must depend upon some other quality, than that of the hardness of the stone. So far, my experiments had proceeded with fresh Water.

Q. 2d. What difference results in the strength of the mortar when made up with fresh, or with Sea Water; the compositions being immersed in the same water?

Balls were made up in the former different proportions; one pair with salt and the other pair with fresh water, and this was several times repeated; the result was, that as to what happened immediately, or within the compass of a few days, there was no apparent difference; but of the balls which remained entire, when kept under water for two, or three months, those made up with salt water appeared, if there was any difference, to have the preference. Hence I concluded, there was no need to burthen ourselves, with carrying out fresh water to the Edystone for making the mortar: and in consequence all future trials, except it is otherwise mentioned, were made with salt water †.

Q. 3d. What difference results from different Qualities of limestone, so far as I could procure the specimens?

Having heard of a lime produced from a stone found at Aberthaw, upon the coast of Glamorganshire, that had the same qualities of setting in water as Tarras, I was very anxious to procure some of the stone; which I did, and burnt it into lime. I found it to require a good deal of fire to make it, by quenching, fall into a fine powder. This stone, before burning, was of a very even, but dead sky blue, with very few shining particles; but when burnt and sifted, it was of a bright buff colour. Having made up a couple of balls, according to each of the former proportions; and also a couple of balls with common lime (by which I mean Plymouth lime) the difference of hardness after twenty-four hours was very remarkable: the composition of two measures of Aberthaw to one of Tarras, considerably exceeded in hardness that of common lime and Tarras, in equal parts: the composition of Aberthaw and Tarras in equal parts was still considerably harder, and this difference was the more apparent, the longer the compositions were kept.

188. THUS encouraged, I was willing to try farther; and particularly to examine the validity of the notion entertained by workmen, respecting Tarras Mortar, that the longer it was kept and the oftener it was beaten over, the stronger it would set: for, as it would be likely to prove a very great incumbrance, in our situation, to keep our mortar in a state of beating for a length of time, and from one time of using to another, it was very material to be thoroughly known, how far this was really the case; and if so, whether, for saving of time (to us most valuable) a greater proportion of tarras might not answer the same end as a longer beating: for it was evident, we should have every moveable thing to carry to and from the rock each tide, along with ourselves.

Q. 4th. Whether Tarras Mortar, after having been once well beaten, becomes better by being repeatedly beaten over again?

\* This, though very contrary to the common opinion of workmen, is supported by the experiments of Dr. HIGGINS, which shew, that Chalk Lime well burnt was fully equal to the best sort of Stone Lime he used; which he esteemed that made from Plymouth marble, for the purpose to which his enquiries were directed; viz. Buildings in the Air. Higgins on Calcareous Cements. Sect. 24.

† In a composition of mortar for Water-building that BELIDOR gives from M. MILET DE MONVILLE, he uses Sea Water for making the mortar of such works as are exposed to the Sea. Belidor, Arch. Hydraul. part 2. tom. 2. p. 186.



To prove this, I made up a couple of balls of Aberthaw lime, one in each proportion above-mentioned, and laid them in a damp place upon a water soaked brick, sprinkled them with water, and covered them with a wet cloth; so that they might be as slow as possible in setting: these I broke down, and beat over again, every morning and night for three days: and then prepared a couple of balls of the same materials afresh, and beat them very well. These balls were, when set, put all together in salt water. Between these, where the composition was equal parts, there was no discernible difference: but of those in which the lime predominated, the preference seemed due to such as had had the repeated beatings; though the difference was not very remarkable. —The same experiments being tried with common lime, the preference was evidently more in favour of repeated beatings, in that composition in which the lime predominated (that is, the common one) than in that of equal quantities. Hence though the practice of workmen is very right, where common lime, and the smaller quantity of tarra, as in the common case, are used; yet where the tarra is not spared, and the lime is of superior quality; the repetition of beatings appears not to be material; and therefore for our use, where nothing was to be spared, that could save time and labour upon the rock, the composition of equal quantities of Aberthaw lime and tarra seemed adapted in the best manner possible to the purpose.

189. I HAD heard that Shell Lime, that is, Cockle or other shells burnt, set very hard and made an excellent mortar for under-drawing, and inside work. It is mentioned in WREN'S Parentalia as having been made use of in St. Paul's Cathedral for this purpose, and found excellent. On trying some of this mortar I found it to set hard, and readily, without any admixture of sand, tarra, or other matter. In short, for water work, tarra scarcely appeared to improve its natural quality. On being put into water, after it was set, it did not dissolve, but did not acquire an additional hardness; on the contrary by degrees it macerated and dissolved, not internally, but gradually from the surface inwards; and hence I concluded it totally unfit for our use. I was afterwards informed, that a part of the work at Ramsgate Pier had been done with this kind of lime, but was afterwards obliged to be taken up, on its dissolving quality in sea water being discovered.

190. HAVING observed how very speedily Plaster of Paris, from a semi-fluid state would set into a hard substance, I conceived it might probably be of some use in our work. On making up a ball as I did with the mortars, but without beating, it very readily set; and did not dissolve on putting it into water; but I soon found that, while in a moist state, it had little firmness, and did not acquire any additional hardness under water; and by continuance, it became less firm: though I do not remember in the time I had it in trial (perhaps two or three months) that it redissolved, either throughout its substance, or by maceration of its surface, like the shell lime\*. I tried many experiments to improve its qualities by admixture, but did not find that either sand or tarra was of any use: I also tried to beat it while in a pulp, which would for a little time prevent its setting, but this did not appear to produce any good effect, either alone, or with admixtures. Indeed I did not find that any thing was likely to give it solidity beyond what it naturally has; unless that after it was dry, it would then drink up linseed oil plentifully; and which, if dried in its pores, would doubtless give it a considerable degree of solidity: but this treatment not being applicable to my purposes, I did not pursue the experiment any further.—However, the great readiness wherewith I observed plaster to set to a moderate degree of firmness, suggested to me this thought, which afterwards proved to be useful; that when there was not time for our cement to set, before it was subjected to the violence of the sea, if it was coated over with plaster, it might thereby be defended till it had time to set; and then, if the plaster should be washed off, it would be of no consequence.

191. THE last species of lime I had an opportunity of trying in these my original experiments, was a kind that was much commended for water-works, and which is produced in the

\* I am lately told, that Plaster of Paris is liable to be perfectly dissolved in a large quantity of water, if suffered to remain in it for a length of time, and especially if the water is frequently changed or much agitated.

county of Devon, at a place called Bridistow, about thirty-five miles north from Plymouth.—I procured a piece of this stone and burnt it: its appearance, both before and after burning, was much like that of Aberthaw, and on a similar trial it answered pretty much in the same manner; but the composition formed with it appeared to be somewhat inferior in hardness: however, it seemed capable of becoming a substitute, in case I met with any difficulty in procuring that of Aberthaw.

192. HAVING now found a species of materials, and a method of compounding them, very competent to our purpose; and having plainly seen, that there was a great difference in the effect, arising from the different nature of lime burnt from different kinds of limestone; and that its acquisition of hardness under water did not depend upon the hardness of the stone; inasmuch as Chalk lime appeared to be as good, as that burnt from Plymouth marble; and that Aberthaw lime was greatly superior to either, for the purpose of aquatic buildings, though scarcely so hard as Plymouth marble; I was very desirous to get some light into some of the sensible qualities, that might probably occasion the difference, or at least become a mark of distinction. I therefore applied to my friend Mr. COOKWORTHY, whom I had found at all times ready to afford me his assistance, wherever his knowledge could be of use to me. He taught me how to analyze limestones: and though my chemical friends will be at no loss upon this subject; yet as it is very possible, that some of my readers may be no more acquainted with chemistry than myself; for the sake of these I will describe the process, as being useful for all those who are concerned in building to know.

193. I TOOK about the quantity of five pennyweights (or a guinea's weight) of the limestone to be tried, bruised to a coarse powder; upon which I poured common aqua fortis, but not so much at a time as to occasion the effervescence to overtop the glass vessel in which the limestone was put; and added fresh aqua fortis after the effervescence of the former quantity had ceased, till no further ebullition appeared, by any addition of the acid. This done, and the whole being left to settle, the liquor will generally acquire a tinge of some transparent colour; and if from the solution little or no sediment drops, it may be accounted a pure limestone (which is generally the case with white Chalk and several others) as containing no uncalcareous matter: but if from the solution a quantity of matter is deposited in the form of mud, this indicates a quantity of uncalcareous matter in its composition. When this is well settled, pour off the water, and repeatedly add water in the same way, stirring it and letting it settle till it becomes tasteless. After this let the mud be well stirred into the water, and without giving it time to settle, pour off the muddy water into another vessel: and if there is any sand or gritty matter left behind (as will frequently be the case) this collected by itself will ascertain the quantity and species of sabulous matter that entered into the texture of the limestone. Letting now the muddy liquor settle, and pouring off the water, till no more can be got without an admixture of mud, leave the rest to dry; which, when it comes to the consistence of clay, or paste, make it into a ball and dry it for farther examination.

194. ON treating common white chalk in this manner, the whole dissolved into a transparent solution; and Plymouth marble, when free from apparent extraneous mixtures, did the same: but, as I found Plaster would not effervesce with the acid, I therefore concluded that it was a peculiar substance distinct from limestone, having nothing calcareous in its composition\*; and therefore that its cementing property depended upon some different principle.—On trying Aberthaw lime in this way, it was dissolved in the aqua fortis; but the solution appeared very dark and muddy, and on examination I found a small quantity of undissolved sandy particles at the bottom, some of them transparent like crystals, but mostly very minute, and of a dirty appearance. The muddy residuum being brought into an argillaceous state, was very tough and tenacious while soft; and when sufficiently hardened, being worked into a little ball, and dried, in that state it appeared to be a very fine compact dark blue clay, and weighed nearly one-eighth

\* Plaster or Gypsum, as I have since been informed, is an earthy salt composed of calcareous matter dissolved in the acid of Vitriol.

part of the original mass. One of these balls having been burnt became a good compact brick, which being of a reddish colour, it from thence appeared, as I was told was the case, that it had an admixture of iron in its composition. On weighing it, I found that it had lost near upon one-fourth part of its former weight in burning. Bridistow limestone, by the same mode of examination, exhibited nearly the same appearances.

195. FROM the experiments now related, I was convinced that the most pure limestone was not the best for making mortar, especially for building in water: and this brought to my mind a maxim I had learnt from workmen; that the best lime for the Land was seldom the best for Building purposes; of which the reason now appeared; which was, that the most pure lime affording the greatest quantity of Lime Salts, or impregnation, would best answer the purposes of Agriculture: whereas, for some reason or other, when a limestone is intimately mixed with a proportion of Clay, which by burning is converted into Brick, it is made to act more strongly as a Cement\*.—This suggested to me the idea, that an admixture of Clay in the composition of limestone, when treated as above specified, might be the most certain index of the validity of a limestone for Aquatic Buildings: nor has any experience since contradicted it; as all the limestones in repute for water-works, that I have met with, have afforded this mark; even the Darkling lime much esteemed for these uses at London, and in the country round about, is plainly nothing but a species of chalk, impregnated with clay, of which it makes one full seventeenth part of the original weight.

196. HAVING thus satisfied myself in respect to limestone, that, if I had not arrived at the best in the world, I had found one so competently good, as to answer every idea of what I could possibly want for the purpose of mortar for the Edystone Lighthouse: I considered that though Tarras was really endowed with those qualities, which had justly obtained it a reputation for water building; yet it was generally admitted to have some properties, that for our use were not quite so eligible.—In the first place, though it will cause most kinds of lime to set and become hard under water, as we have seen by several examples; yet if the Cement grows dry by a gradual exposure to the air, it never sets into a substance so hard as if the same lime had been mixed with good clean common sand; but is very friable, and crumbly; and if, after it has acquired a considerable degree of hardness by immersion in water, it is then exposed to the air, it loses a considerable part of its firmness, and also becomes crumbly: though according to my observation, it never becomes so much so, as if it never had acquired a greater hardness by a submersion in water.—For this reason, though there is no necessity for using it where the work will always be dry, or subjected only to the rain; and though it may be considered as being always wet, where it is in the joints of a massive work immersed every tide; yet in our case, those parts which were above the ordinary swell of the tide and sea, and liable to be wet only in storms, and hard gales of wind; and which, properly speaking, could never wholly be immersed, so that the pores might be thoroughly soaked with water; in such a state, between wet and dry, or of being wet and dry by intervals, tarras is known not to answer well. The knowledge, that in parts so circumstanced, the mortar is the most liable to fail, and to be affected by the frosts, whatever its composition may be, has put artificers upon trying other mixtures; one of the principal of which was communicated to me by Lord MACCLESFIELD in his letter as under†.

\* It is not to be wondered at, that workmen generally prefer the more pure limes for building in the Air, because being unmixed with any uncalcareous matter, they fall into the finest powder, and make the finest paste, which will of course receive the greatest quantity of Sand (generally the cheaper material) into its composition, without losing its toughness beyond a certain degree, and requires the least labour to bring it to the desired consistence: hence mortar made of such lime, is the least expensive; and in dry work the difference of hardness, compared with others, is less apparent.

“ London, 14th April, 1757.

† “ SIR,

“ I was favoured with yours in due time, and should have sooner returned my thanks for it, had I not waited for a more particular account of the manner of making the Ash Mortar, than I could give you merely from my memory: and for which I therefore sent into the country, and received it only yesterday. It may not, however, be improper to inform you, that the lime



197. ANOTHER property of *tarras* mortar is, that when kept always wet, and consequently in a state most favourable to its cementing principle, it throws out a substance something like the stony concretions in caverns of limestone Strata, called *Stalactites*; which substance from the *tarras* comes to a considerable degree of hardness, and in time becomes so extuberant as to deform the face of the walls; and when smoothness and regularity of surface is wanted, as in navigable Sluices, mill Conduits, &c. it becomes necessary to remove its roughness by tools; for otherwise the *tarras* mortar will grow so much in the joints of these conduits, as to knock off the Floats or Ladle-boards from the wheels. I was therefore desirous to try the properties of other substances, said to be useful in making calcareous mortar to set in water; one of which I had found mentioned by *Belidor*\*; and that is the *Terra Puzzolana* found in Italy.—In making enquiries how some of this might be procured from thence, I very fortunately learnt, that there was a quantity of it then in the hands of a merchant in Plymouth; which had been imported as an adventure from *Civita Vecchia* during the time Westminster Bridge was building; and which he expected to have disposed of for that work to a good advantage; but failed in his speculation: for having found that *tarras* answered their purpose, neither Commissioners, Engineers, nor Contractors, would trouble themselves to make a trial of it, and therefore refused it. This proved a lucky circumstance to me; for it might otherwise have been many months before I could have got any for trial; and afterwards as many more, after finding it to answer, before I could have got a quantity from Italy for actual service.

198. ON trial of this, I soon found it in every respect equal to *Tarras*, as far as concerned the hardening of water-mortar, if not preferable to it. And the merchant having had it long by him, and the keeping it being an inconvenience, he declared himself desirous to get rid of it, considerably under the price of *tarras*; I therefore made no hesitation in purchasing the whole quantity; and had the satisfaction to find, so far as time would give leave, antecedent to my actual use of it, not only that it appeared fully to answer every good end of *tarras*; but in letting it dry immediately, or keeping the balls sometimes under water, and sometimes in the open air, in which latter state they were suffered to become perfectly dry; I perceived that in every state of it, if made into a mortar with *Aberthaw* lime, it exceeded in hardness any of the compositions commonly used in dry work; and in wet and dry, or wholly wet, was far superior to any I had ever seen or experienced; for, when the balls were immersed in water, they appeared to acquire hardness progressively; which progress, while they were out of the water and became dry, was indeed suspended, but yet they retained the hardness they had there acquired.—With respect to those balls that were kept constantly under water, they did not seem inclined to undergo any change in form, only to acquire hardness gradually, insomuch that I did not doubt but to make a cement that would equal the best merchantable *Portland Stone* in solidity and durability.

199. ALTHOUGH, in my main object, I had by degrees succeeded to my wishes; yet there was still one circumstance more that required investigation.—My reader will perceive from the nature of the bond that I proposed in my work (see Plate No. 13.) that one half of each piece of stone, being lodged in a dovetail recess, wherein it was locked fast on three sides, there was no way to get them into their places, but by letting them down perpendicularly: in consequence of this, mortar beat up and prepared in a manner similar to what has been specified, could

\* that is generally made use of in my neighbourhood is made from chalk, of which we have great plenty: though I am sensible that

Stone Lime is much stronger, and better; and that the strength and goodness of the Ash Mortar depends, in a great measure, upon

its being well beat, in which there is no danger of excess. The manner of making it (as sent to me from the country) is as follows.

Take of lime that is very fresh, two bushels, and take of wood-ashes three bushels. Lay the ashes in a round trench, and the

lime in the middle of the trench; then slake the lime, and mix it well with the ashes. Let it lie thus till it is cold, and then beat

it well together; and so beat it for three or four times before it is used.

This mortar thus made is reckoned, by our bricklayers, to be much more strong than that prepared with *tarras*, in places that are

at sometimes wet, and at others dry; though they acknowledge, that the *tarras* mortar is better in work that is constantly under water.

It will give me much pleasure if this communication should be of any service to you at any time, and especially in carrying on

the work you have now in hand, which is of so great importance, and of such public utility."

\* Architecture Hydraulique, Part II. Tom. II. p. 186. This indeed is pointed out by *Vitruvius* in his *Architecture*, B. II. Cl. VI.

only be applied to the ground joint, or under-bed of each stone : the upright, or side joints (supposing the work to be close put together) could not be lined with any quantity capable of filling the whole joint ; for if that was attempted, the stone, in being lowered into its place, would carry down the mortar, upon the sides, along with it ; leaving so little, as not to make those joints solid and full. It therefore must become necessary, to consolidate the upright joints, by pouring in liquid mortar, commonly called Grout, in so fluid a state, as to run into every cavity and crevice. —The common way then in use of doing this was, by putting as much slaked lime into water, as when stirred would be sufficiently fluid to answer the end ; which is called puttying. And the best way then in practice was, to put the ingredients together according to the due proportion, to make the species of mortar intended, and with as much water as would render them fluid ; and after stirring them well together, to pour the mixture into the joints.—Seeing therefore of how much importance it was to the solidity of our work, to attain the best method of grouting ; and perceiving how great a degree of solidity was attained by the well beating of mortar, in comparison of that which was only sparingly beaten ; it occurred to me to try the following experiment.

200. I TOOK about three times the quantities of materials, that were necessary to make a ball of the common size I used in my other experiments, and beat them well together, as I used to do for the best mortar ; I then took the like quantities, and put them well mixed, but unbeaten, into a quart mug, with as much water, as that, when well stirred, the compound might be capable of being poured, like metal, into a mould. I then gradually added water to the beaten mortar, so as to reduce it by beating to so soft a pulp, as to require a vessel to contain it, and put it into another quart pot, adding water by degrees, and stirring it well till this, like the other, was also capable of being poured into a mould.—Both the pots, with their contents, were then deposited where they might be at rest ; and within an hour the gross matter of both had separated from the water by subsiding to the bottom, leaving the water clear at top.—The next day I perceived so entire a separation of the materials from the water that it had become perfectly clear in both. On putting down my finger to the sediment of the unbeaten materials, I found it quite loose and muddy, but making more resistance underneath than at the top. The dissolved mortar made a resistance equal to that of soft clay at the top, and of stiff clay underneath : and afterwards examining them both from day to day, with a blunt-pointed stick, I found them to acquire a progressive firmness : for, in a week the unbeaten stuff was become clayey, being soft at top, but of a stronger consistence below ; while at this time the dissolved mortar was scarcely penetrable with the stick at top, and seemed to have acquired a stony hardness below. In the compass of a month both mixtures were grown so hard as not to be easily separable from the vessels : I therefore broke the pots, and found the contents of both had acquired a stony consistence, each hardest at the bottom : that of the dissolved mortar being considerably harder than the other, that is, of a moderate stony-hardness ; not indeed equal to that of balls of the same age and composition, yet of a degree of hardness very satisfactory, and competent to my purposes. And as it appeared that those compositions, notwithstanding their being originally in a liquid state, and always having had water upon them, yet acquired a stony hardness gradually ; and that though they did it in a slower degree than undissolved mortar ; yet in length of time, the grout made of the dissolved mortar might become as compact as the undissolved mortar ; I had therefore no doubt of being able to unite the whole of the materials of my building into one solid mass of stone.

To avoid prolixity, I have mentioned these experiments as single trials ; but they were all repeated, and some of the principal ones several times. I also made trials of other compositions, which for the same reason I think it unnecessary to mention ; particularly several mixtures of lime with Plaster ; and though I am aware that the plasterers use some compositions of this kind with advantage in their works, yet when subjected to the test for water-works, that I had established for the conduct of my own experiments, I found nothing useful in all the mixtures of lime with plaster, nor even of tarras and puzzolana with plaster ; as the result was, that they rendered the plaster less speedy in setting, and the plaster rendered the compound, that would have resulted from the other ingredients, less firm, and more crumbly.

201. THE inquisitive reader will undoubtedly be desirous to know the nature of the two substances of so much consequence in water building; viz. Tarras and Puzzolana: and I wish I was able to satisfy him in this respect, as well as I trust I have been in the application of them to use. But if I tell him what has come to my knowledge and information, as this may incite the learned Naturalist and Chemist to enquire further, so as to give us more accurate accounts of their origin, natural composition, and properties, what I have to say on this head may have its use.

When I was in Holland in the year 1755, I made it my business to enquire, as particularly as I could, concerning the Tarras. I there saw the tarras stones, and was informed that they were brought down the rivers from Germany, (if I remember right, from the province of Liege) where this material is dug in mines under ground, and lies in regular Strata. I found it in lumps of various sizes, from the bigness of a pea to that of a middle-sized turnip. This stony substance is called in Holland the Duif Steen, signifying the Dove Stone, as I was told: it is of a light greyish colour, or ash colour, is rather tender than hard, and is very porous, somewhat resembling a pumice-stone. It is brought to Holland in the same state as it is taken out of the earth, and the only art that is there employed in preparing it for use is, to reduce it to a coarse powder, by means of mills for that purpose, which I saw. It is beat by iron-headed Stampers upon an iron bed, till it passes through a sieve of a certain fineness, equivalent to one of ours, having about eight wires in an inch; it is then ready for use, and is generally sent from Holland in casks.—There seems to be nothing calcareous in its composition, for aqua fortis dropped upon it only wets it like water: to me it much resembles some petrifications that I have seen; but my more learned friends seem to be of opinion that it is a Lava\*.

202. THE Puzzolana is also a porous substance, and, like the tarras, produces no effervescence with aqua fortis: it has much the appearance of being a volcanic production, is of a brown colour, and, as my friend Mr. COOKWORTHY told me, contains iron; it has the look of an iron ore rendered porous, or burnt to a cinder by fire. It is said to be found in large quantities in the neighbourhood of Mount Vesuvius and in several other parts of Italy. That which was the subject of my experiments, as well as the best of what I have since caused to be imported, or have seen, was from Civita Vecchia: I have seen a kind of puzzolana said to be brought from Naples, of a less ruddy and more grey colour, but on trial I did not find it to be near so strong as the former; for, one half of the quantity from Civita Vecchia would cause a composition of calcareous mortar to set harder in water, than that from Naples would do.—It is said, that the ancient baths and water-works of the Romans were built with this kind of mortar; and their duration has, it seems, proved the validity of the composition: but I apprehend, unless they have the Lys limestone in Italy†, it was reserved to the Edystone, to have those two materials first combined; and of consequence, so far as has yet appeared, the perfect composition of water mortar was now first ascertained to be a proper mixture of blue lys lime and puzzolana.

203. SEEING that both tarras and puzzolana agreed in two of their obvious properties, porosity, and resistance to the action of aqua fortis, as well as the hardening of calcareous mortar under water; and also, as volcanic substances, in having passed the fire‡, I was induced to try experiments on several porous substances, that appeared to have some similarity to them; such as Pumice Stone, Coal Cinders, Brick and Tile Dust, and such like. I found them all possessed of an absorbent property, which caused the mortar made with them to set somewhat more quickly than when made up with sand only: so that where hardness is expected from drying, and time is wanted to produce the effect fully, they may be useful to this end, in procuring it to be done more speedily; but being, when set, immersed in water, they did not appear to possess any

\* I now understand that this substance, when prepared for use, is by the Dutch called Tras, from which our appellation of Tarras undoubtedly originates. It is by some said to be brought from Andernach. It is supposed to be the same as the Peparino of the Italians; which, as I understand, according to BERGMAN, is a concretion of Volcanic Cinders.

† Lys is the general term for strata of stone of the species of Aberthaw, in several counties.

‡ If Tarras and Puzzolana are much of the same nature, it would be curious to know why one substance causes the mortar to alter its form, or, as the workmen call it, grow in the joints under water; and the other to lie quiet.



powers of resistance to their dissolution, more than the same lime would do with common sand, if, by a little more time, the composition was become equally set.

204. HAVING made up my mind, that the proper composition for our mortar was, lime of blue Lyas, and Puzzolana, in equal quantities; and having procured a sufficient quantity of puzzolana; it was now time to think of securing to ourselves, a sufficient supply either of lyas lime, or limestone.—In making enquiries on this head, I learnt that, for doing such water building as they wanted at the city of Exeter, they procured the blue lyas lime ready burnt, from Watchet, a small sea-port of Somersetshire, lying upon the Bristol Channel, almost right across the Peninsula; but which, though near forty miles north from Exeter, they were obliged to carry on horses backs: for if they waited to have it brought by sea, round the Land's End, it would, in the length of time thus necessarily expended, attract so much moisture from the air, that it would be reduced again to the state of Limestone; after which, it would not fall into powder by quenching: and even if it got wet in the land carriage by the fall of rain, this would happen in such a degree, that they were obliged to quench it with boiling water; and if that would not do, it was concluded to be spoilt.—Upon this information, it appeared to me, that the best way of procuring it in a sufficient quantity for our use would be in the stone, and to burn it in our works at Mill Bay: but as the right management, and a thorough knowledge, of this article appeared of the utmost consequence; that I might get all possible information concerning it, I determined to take a journey for that purpose to the country where it was produced, and in common use.

205. I SET out therefore on the sixth of April, and first went to Minhead, another small port upon the Bristol Channel, a few miles farther west than Watchet; having been informed, that the Pier of Minhead had been built partly with lime from Watchet, and partly with that of Aberthaw; which lies also upon the Bristol Channel, nearly opposite to it, upon the Welch coast.—On examining the works of this pier, it appeared to me, that those done with Watchet lime were quite as good, or even preferable to those done with that from Aberthaw; the parts so done being pointed out to me by a workman upon the spot, that had been employed in the erection: but as all agreed that they were the very same Strata of lyas-stone, that were found on each side the Channel, though at the distance of twenty miles; what difference there was, might very easily arise from a difference of treatment in making the mortar, or a more favourable season of the year when the work was executed.

In passing through Dunster, from Minhead to Watchet, as all the buildings in that part of the country were erected with lyas lime, I took care to remark the appearance of every kind, both wet and dry. And though the workmanship in general appeared but coarsely performed, yet the mortar bore to me the evident marks of being excellent; for, wherever I saw it, however coarsely it was done, yet it appeared full and flush in the joints, without cracks, or losing its original skin, or becoming crumbly; as often is the case with mortar of a tender kind, after having gone through two or three winters, or more: and in one place I remarked the foundation of a little bridge, that by some accident had been driven down; but the mortar, over which the current was making its way, I found, on trying it with my knife, to have acquired such a stony hardness, as, with a coat of moss, effectually defended it from the action of the water; yet it was considerably inferior, in hardness and firmness, to the balls I had made with lyas lime mixt either with Tarras, or Puzzolana.

206. ON my arrival at Watchet, I first examined the pier there, which, though but a rough piece of work, I found to be quite satisfactory, as to the mortar part; and learnt, that they made no scruple of mixing it up with Sea water.—On viewing the situation, in which the Lyas Stone lies here in its natural bed, I found, that the sea retreated from the shore to a considerable breadth, or distance, at low water; and in this inclining surface very many Strata of lyas stone, of different thicknesses, appear, chiefly from four or five to ten or eleven inches thick, but all apparently of the same quality; being indiscriminately taken by the lime-burners according as they find them most convenient to be come at.—These Strata are not much inclined to the horizon,

but more so than the general inclination of the shore; and therefore, as they dip towards the low water mark, a vast number are exposed to view. The Lyas seems universally to lie in a bed of uncalcareous laminated blue matter, and which, when exposed to the weather, seems to turn to much of the same kind of looking clay, that I found by my experiments to be intimately mixed with the calcareous Strata.—The bed, or Matrix in which the Lyas lies, being of a softish perishable nature, it is found easy to detach the stone with an iron Crow; and therefore though there is plenty of the same kind of stone to be found in Strata within land; yet as there is no great demand for this kind of lime, the lime-burners can procure what they want in sufficient quantity from the shelving sea-shore just described, with more ease than by laying open the ground.

It perhaps will seem wonderful, that for a lime so excellent in quality there should be no great demand; for in reality I found but one small lime-kiln; and that not kept constantly at work: but considering the occasions of the neighbouring country for building-lime not to be great; and the charge, trouble, and difficulty attending the carrying it to a distance to be considerable; and that it does not suit the purposes of Agriculture, even upon the very spot where it is produced, the wonder will undoubtedly cease: and I was informed by the lime-burners themselves, that for the use of their own farm, they were obliged to get lime from the rocks of St. Vincent near the Hot Wells of Bristol; or of that quality, at the distance of more than 40 miles: for, they told me, were they to lay their own lime (though reduced to a fine powder) upon the land, the first shower of rain would turn it all to stone, without affording any sensible cultivation to the land: and as the rocks of St. Vincent are somewhat like the Plymouth marble; this circumstance affords another proof, that the qualities of lime, for different uses, do not depend upon the hardness, but upon the specific qualities of the stone from whence it is burnt.

A question now arose, how I was to get supplied with lime in the quantity I wanted; as I found that the lime-burners were under a prohibition from the lord of the manor, to send away unburnt stone: and also that the difficulties of getting it on horseback across the country to Exeter, &c. were not exaggerated: but I was informed, that this lime, if burnt to a due degree, and quenched hot from the kiln, would fall to a powder as freely as any other kind of lime; and that to prevent its imbibing moisture from the air, they always mixed it up for use, as soon, or as hot (as they term it) as possible, and having so done, find it to set the stronger, when used for works under water. They also informed me, that, if kept close from the Air, it would preserve its virtue for a considerable length of time. Consequently nothing in this mode was to be depended on, but Water tight casks; the procuring of which without great expence and loss of time, appeared a considerable difficulty; as it was first apprehended they must be brought from Bristol.—On enquiry however I found that much cyder was produced in this part of the country; and fortunately it was a time of the year, when many of the casks for this liquor were empty.—What quantity of casking would hold a given quantity of burnt lime was a matter untried; as this mode of sending it away was not in use with them.—I wished much to see the process of burning it, and quenching it when burnt; and therefore by way of investigating what quantity of casking would be wanted, I ordered a kiln of lime to be put on, and having procured some Cyder casks, and the lime to be quenched and sifted, immediately from the kiln; it slaked as I had been told, very freely, affording a very soft impalpable powder. We proceeded upon the package as follows.—I caused a quantity of their burnt lime, which they delivered for a Hogshead and a half, to be weighed from the kiln, which was  $4\frac{1}{2}$  cwt. This being quenched, and sifted, the dry meal was the same weight as before: so that the water it had imbibed in quenching compensated for the waste in sifting: and in this state the produce from the hogshead and half, of lime measure, could be rammed into a cyder hogshead cask; so that in reality it was of less bulk and weight than it would have been if sent away unslaked, and of considerably less weight than it would have been if sent in the unburnt stone; which, in common with other limestones, is found to lose a considerable part of its weight in burning. The quantity therefore of 20 tons, which I proposed to procure, would be packed in 90 such hogsheads. I therefore employed a reputable merchant there to procure the casks, hire a vessel, and forward the lime; and 135 hogsheads of burnt

lime, rammed into 80 casks, containing in the whole 110 hogsheads wine measure, arrived at Mill Bay soon after my return\*.

207. THE blue Lyas stone of Watchet is of a dead sky blue†, of a very fine even frosted grain when broken, with few shining particles. There is also in several parts of that county another kind of limestone, which they call the white Lyas; which has the same kind of grain, with a small quantity of shining particles, and has much the same appearance, the colour only excepted, as the blue; it also lies in Strata of nearly the same thickness; and though of a chalky whiteness, is quite as hard, or rather harder than the blue: yet it is held in no estimation for Water Works; and at which indeed when I had analyzed it, I did not wonder, as I found it almost wholly to dissolve, and become suspended in aqua fortis. The Residuum, which was very small in quantity, was of a light reddish colour, and contained a few particles of transparent crystals.—In passing the cliffs upon the sea coast between Minehead and Watchet, I found frequent veins of Gypsum or plaster, interspersed with Strata of limestone, of a kind having impressions of fossil shells included in it; but observed no appearance of marks of fossil shells in either the blue Lyas of Watchet, or the white Lyas of Somersetshire.

208. BEING now determined as to the composition of the mortar for the Edystone; I might here very properly put a period to this part of my subject: but my reader, after giving him the preceding account of its great utility, will not perhaps be displeased, if I communicate to him the principal observations that have occurred to me in a course of thirty years practice in water building.

As nothing could succeed better, or be more satisfactory, than the mortar I used, as will be further seen in the course of my proceedings; I wished to examine all those limes which discovered any degree of fitness for Water Building; and more especially, if possible, to find out a substitute for Tarras and Puzzolana in this kingdom; that we might be in possession of all the best materials for water building within ourselves: and though I own I have not succeeded with respect to the latter, so far as my ardent wishes led me to hope; yet as I have since learnt how to compose water cement with a far less proportion of the foreign materials than I at first used, and upon the whole at a much less expence, I trust this investigation will be thought material and useful.

*The Limes that I have since examined are as follows:*

209. 1st. THAT of Barrow in Leicestershire, of which we used considerable quantities in the Calder Navigation. I never was at the quarries, but having procured some of the unburnt stone, I found it had the appearance of blue Lyas, only somewhat of a more yellow tinge, and more of the slate kind: it burns to a buff coloured lime like that of Aberthaw and Watchet, and on dissolution affords nearly  $\frac{2}{10}$ ths of its original weight, of blue clay, with a minute quantity of dirty grey sand; so that I have no doubt of its being the true Lyas, though perhaps of a less perfect composition than that bordering on the Bristol Channel. It contains more clay, can be carried further, and remains longer without injury‡; but in the actual use thereof as mortar, it does not appear to me to acquire quite so firm and stony a hardness, as the blue Lyas of Somersetshire. It makes however excellent water mortar, if properly treated, and will very well serve in those parts of the kingdom that are more accessible to the Trent navigation, than that of the Bristol Channel.—In fact, in travelling from Glamorganshire through Monmouthshire, Gloucester-

\* This mode of conveyance was in reality so successful, that several casks of this very lime which remained, after the Lighthouse was finished, were afterwards carried into Yorkshire, and used in the most critical part of the works of the River Calder, and remained perfectly good from the year 1757 to the last used in 1764: only, that as it had become somewhat lumpy, the fine powder was sifted out, and the rest by gentle bruising was reduced to powder, so that the whole passed through a fine wire sieve.

† This was the description of it at the time, but on breaking a specimen of it that I have now by me, I should rather say, it is of a dark lead colour, somewhat inclining to brown. I therefore suspect it has altered its colour by keeping.

‡ The practice in sending it away is, in the burnt stone, packed unquenched in casks that have held sugar and grocer's dry goods; but where the demand is considerable, I have practised myself the getting the unburnt stone, and calcining it upon the place.



tershire, and Warwickshire, into Leicestershire, I found such frequent instances of ordinary walls and cottages built with stone that appeared to me to be blue Lyas, the mortar also being of the same hue, that I have not a doubt, but that the curious naturalist, in making this expressly an object of search, would be able to trace it from Aberthaw and Watchet quite to Barrow; though probably with several breaks, as is usual in the arrangement of the Strata of the earth. At Bath they pave the streets with a species of Lyas; and to render the pavement more durable by keeping out the wet, they joint the paving with mortar of the same kind of stone.—The Bath Free Stone is of the pure calcareous kind; and it is remarked, that when it is walled with this kind of mortar, which is frequently, if not generally, used for the purpose, the joints are more permanent, and resist the weather even better, than the stone itself: and it is this circumstance, which gives that peculiar firmness to be observed in the light and thin walls of the buildings of that city.—From Leicestershire it appears to pass by the Vale of Belvoir into Nottinghamshire and Lincolnshire; for, a species of this kind of lime is used in some of the buildings about Newark\*; and the Great North Road is repaired with the blue Lyas stone for a considerable length in the post stage between Newark and Grantham: at Long Bennington (a village of Lincolnshire, through which the road passes on that stage) there is a lime-kiln for burning it. I have not yet seen it farther north than this, nor any where north of the Trent. The limestone at Long Bennington contains  $\frac{1}{10}$  blue clay.

210. 2d. PERHAPS nothing will better shew that the qualities of lime for water mortar do not depend on hardness or colour, than a comparison of the white Lyas of Somersetshire, (which, though approaching to a flinty hardness, has yet a chalky appearance) with what is called near Lewis in Sussex, the Clunch Lime; a kind of lime in great repute there for water works, and indeed deservedly so. This is no other than a species of chalk, not found, like the Lyas, in thin Strata, but in thick masses, as chalk generally is: it is considerably harder than common chalk, but yet of the lowest degree of what may be denominated a stony hardness; it is heavier than common chalk, and not near so white, inclining toward a yellowish ash colour.—This stone, when analyzed, is found to contain  $\frac{1}{10}$ th parts of its weight of yellowish clay, with a small quantity of sand, seemingly of the crystal kind, not quite transparent, but intermixed with red spots. Hence the fitness of lime for water building seems neither to depend upon the hardness of the stone, the thickness of the stratum, nor the bed or matrix in which it is found, nor merely on the quantity of clay it contains: but, in burning and falling down into a powder of a buff coloured tinge, and in containing a considerable quantity of clay, I have found all the water limes to agree. Of this kind I esteem the lime from Dorking in Surrey to be; which is brought to London under the idea of its being burnt from a Stone, and in consequence of that, of its being stronger than the chalk lime in common use there; though in fact it is a chalk, and not much harder than common chalk: it contains  $\frac{1}{10}$  part of light coloured clay of a yellowish tinge.

211. 3d. THERE is in Lancashire a lime famous for water building, called Sutton lime: I have lately had an opportunity, by favour of JOHN GILBERT, Esq. to get a specimen of the stone in its natural state. I had long since seen it in the Duke of BRIDGEWATER's works both in the burnt stone and slaked, made up for use, and in the water. I observed that it agreed with the Lyas in being of a buff Cast. The stone itself is of a deep brown colour, and the piece I have is from a stratum about three inches thick, with a white clayey coat on each side. The goodness of the quality, as water lime, does not therefore consist in the colour before it is burnt; for we have already seen blue, whitish, and now brown, to be all good for that purpose; but they all agree in the colour or hue, after they are burnt and quenched: and having analyzed the Sutton limestone, I find it to contain not only near  $\frac{1}{10}$ th parts of the original weight of the stone of brown or red clay, but also  $\frac{1}{10}$ th of fine brown sand; so that in reality I have seen no lime yet, proved to be good for water building, but what, on examination of the stone, contained clay: and though I am very far from laying this down as an absolute Criterion, yet I have never found any limestone containing clay in a considerable quantity, but what was good for water building; and limes

\* The lime quarries from whence Newark is supplied with this kind of lime is from the village of Cuddington, about 24 miles S. E. from Newark, and betwixt the North Road and the Trent.

of this kind all agree in one more property, that of being of a dead frosted surface on breaking, without much appearance of shining particles.

212. SINCE the above was written, I have had the opportunity of examining others of the Water Limestones. I find a species of lime has been used in some of the works about Portsmouth, and recommended as very good for water building, where the expence of Tarras mortar made with chalk lime could not be afforded. It is called Grey Lime, as having been burnt from a species of stone called Grey Chalk. This by inspection I observed to agree so nearly with the Clunch lime I had formerly observed near Lewis (and then analyzed) that in a consultation with His Majesty's Engineers concerning certain works at Portsmouth, I ventured to recommend it to be used in those works, in preference of common Chalk Lime, for forming a proper Water-Cement. This Grey Lime goes by land carriage from the parish of Berryton near Petersfield in Hampshire to Portsmouth. I visited the place, and observed that the country thereabouts was of this kind of chalk; and they call it here Grey lime, by way of distinction from common chalk or white lime: yet in its colour, hardness, and appearance both before burning and after, it is so like the Sussex Clunch before described, that I would not undertake by sight to distinguish them. Its appearance was also similar to that of the Darking lime before mentioned; and though the Grey Lime afforded, on dissolution, a less quantity of clay than Sussex Clunch, yet it yielded  $\frac{1}{4}$ th part of clay; which is a considerably greater proportion than the Darking lime affords; and yet I have proved this last in use to be a very competent Water Lime.

In my return from Portsmouth in April 1787, I recollected that about twenty-five years ago I was consulted about putting on foot the extension of the navigation of the river Wey from Guildford to Godalmin; and being then shewn the different chalk pits in the neighbourhood of Guildford, I recommended it to the resident surveyor to make use of one, in preference to the rest I saw, for building the locks, &c. merely because it had a clayey look; not imagining at that time (which was considerably antecedent to my acquaintance with the Sussex Clunch) that any very good water lime could be produced by any kind of Chalk. This induced me now to visit Guildford Lock; and in going thither, I found the hawling track for the navigation by horses, made good and covered with this very chalk stone broken small: and on examining the lock I found the mortar joints of the brick walling very complete, especially where they were frequently immersed in water.—On bringing away a fragment with me for examination, I find it to contain  $\frac{1}{4}$ th parts of a dark coloured clay: the stone, however, is of a yellowish hue, much like all the chalks I have mentioned as containing clay.—Whether this lime has by these or any other means become known in the neighbourhood of Guildford, as peculiarly good for water works, I had not the means then of getting proper information: but whether so, or not, this may prove an useful hint to the London Builders, as these lime-stones may, by means of the water-carriage, be brought raw down to London, and burnt here; where coals are cheaper than at Guildford: and I am also led to think, that the curious naturalist will find some connection of this lime-stone to subsist through all this range of Chalk Hills, from Lewis to Petersfield: and probably from thence into Surrey, to Guildford and Darking.

In travelling the west road from Bridport in Dorsetshire to Axminster, the country puts on much the appearance of the Blue Lias; and from a shard I broke off from a wall at Axminster, I have proved that it contains clay in considerable quantity; but was particularly happy in being informed from the ocular testimony of my highly respected friends the honourable Mr. CAVENDISH and Dr. BLAGDEN, the blue Lias actually exists in quantity at Lyme\* in the same county; and is there burnt into lime for sale: which place being a small Sea-port, upon the strength of this information, I not only recommended it in 1787 to be used in the King's Works at Plymouth, instead of lime from their own marble, where water is concerned, but propose also to use it for the same kind of works at Ramsgate harbour. And I have not the least doubt, but that after it is known, what to look for, good water lime will be discovered in many distant parts of this

\* Lyme being almost right across the Isthmus, and not above forty miles distant from Watchet, it is probable this Stratum is found at intermediate places. Since the above was settled for the press I have been at Lyme, and have had the opportunity of confirming the above from my own ocular inspection. There is a small limekiln upon the pier, (or Cobb as called;) but what goes away by water, is chiefly in the unburnt stone.

kingdom, either of the Lyas or the Chalk species; which last, though seemingly very distinct, yet so nearly conduces to the same end, that (exclusive of my original partiality) I am almost at a loss which to prefer.

The following Table contains, in one view, the account of nine different Water limestones that I have already particularly mentioned to have analyzed.

No.	Species of Limestone.	Proportion of Clay.	Colour of the Clay.	Reduction of Weight by burning.	Colour of the Brick.
1	Aberthaw . . .	$\frac{1}{11}$	Lead colour	4 to 3	Grey stock brick.
2	Watchet . . .	$\frac{1}{15}$	The same	4 — 3	Light colour, reddish hue.
3	Barrow . . .	$\frac{1}{11}$	The same	3 — 2	Grey stock brick.
4	Long Bennington .	$\frac{1}{12}$	The same	—	Dirty blue.
5	Sussex Clunch . .	$\frac{1}{10}$	Ash colour	3 — 2	Ash colour.
6	Darking . . .	$\frac{1}{12}$	The same		
7	Berryton Grey Lime	$\frac{1}{11}$	The same		
8	Guildford . . .	$\frac{1}{10}$	The same		
9	Sutton . . .	$\frac{1}{10}$	Brown		

213. UPON the subject of a Succedaneum for Tarras or Puzzolana, I have not seen any thing similar in appearance to Tarras, but what has been of the calcareous kind; but as the puzzolana was found to contain some iron, and I had seen masses of gravel strongly cemented (as it appeared to me) with nothing but pieces of malleable iron turned to rust, I had better expectations of success from the iron tribe. I therefore tried the scales that fall from the iron at a smith's anvil, which have long been known to be an excellent ingredient in making calcareous cement, and particularly where exposed to weather, or where water is concerned; and which being well powdered, and mixed with lime, in the same proportion, and treated in the same manner, as puzzolana, I found (so far as I could observe) to produce an equal effect.—A peck of smith's forge scales is easily collected occasionally, to do a small Job; but to procure four or five tons, would be far more expensive than to bring so much puzzolana from Italy. With a view therefore to works requiring large quantities, I tried Iron Ore, after it had passed the fire, and undergone what is commonly called calcination.—This being powdered, I found had a very good effect in water mortar, in causing it to set speedily, in preventing cracks, and finally, in hardening it. On this account it was used in the Calder Navigation, for the inside mortar of the best work, and for the face work of the subordinate parts; but its strength in hardening lime was far inferior to that of Puzzolana or of Forge Scales. What I used was the siftings of the iron stone, after calcination at the iron furnaces; which being deemed too small and light to go into the furnace, was thereby the better adapted to my use. I found that at the iron works it had been frequently made use of, to mix with lime in making mortar for the construction and repair of the water-building part of their own works; and the parts so sifted not being too large for the joints of their masonry, and having it in plenty at hand, they used it as it was; but after a land carriage of several miles, when brought to us, we ground it on a mill, to open its qualities and make it more effectual, as well as go further. This material, among the furnace men in these parts, is called Minion\*.

214. MINION, or iron stone burnt where it can be had in plenty, is a good succedaneum for puzzolana and tarras; and if it is made up with lyas, or other proper water lime, in equal quantities, will make a mortar more firm and hard than common lime, made up with the common

\* Minion is supposed by Mr. MICHELL to be what chiefly falls from the outside of the lumps of the iron stone, and therefore containing more clay.



quantity of *tarras* or *puzzolana*\*: and hence we may be said to have materials within ourselves, to serve the general purposes of water works; but not so perfectly and completely, as by the use of either of the foreign materials above specified.

Wherever I have met with a reddish, or a brownish stone, I have generally made trial of it, but never yet found any thing to answer so well as *forge scales*; except once, that I picked up a kind of coarse deep brown sand stone, somewhat of a tender nature; which having burnt, powdered, sifted, and mixed with slaked lime, I made into a ball, and it proved of equal firmness with *forge scales*: but as it was a fragment found upon the surface of the earth, intermixed with others of different colour and kind, without the appearance of my being able to procure a quantity of it, I saw no probable use likely to result from this discovery, further than that of the reason for which I mention it; which is, that of demonstrating the existence in nature of the material we want, in this kingdom, if we could but tell where to find a quarry, or sufficient stratum of it; in which, though I have not succeeded myself, yet others may find a quantity either of this, or something equivalent to it†.

215. I COME now to shew the means I have used to make a given quantity of *tarras*, or *puzzolana*, produce a greater quantity of good Water Mortar, than either the common composition, where the dear material is sparingly used; or that I used at the *Edystone*, where nothing was spared that had the appearance of being of service.—And if upon this head, I should somewhat enlarge, I flatter myself, I shall be forgiven by a majority of my readers.—Limestone, as it is now generally known, loses about  $\frac{1}{3}$  its weight by burning, but shrinks an inconsiderable quantity in point of bulk‡; but upon quenching it, when fully burnt, it falls freely, and will produce somewhat better than double the quantity of powder or slaked lime, in point of measure, that the burnt limestone consisted of; and this will be nearly the case, whether it is common lime or water lime. Supposing it common lime, if this is beat into a paste with a sufficient quantity of water, it will not in this state occupy quite half the space it did before in powder; but if to this paste from two measures of lime, we add one measure of *tarras*, which makes the ordinary composition of *Tarras Mortar*, the quantity will be enlarged, so as to produce about 1  $\frac{1}{2}$  measure of mortar; and then the bulk will be something greater than it was in either the burnt or unburnt stone§.

216. THE use of sand in mortar, so far as I have been able to observe, is twofold; 1st. To render the composition harder; and 2dly, To increase it in quantity, by a material, that in most situations is of far less expence, bulk for bulk, than lime. As there is no apparent change in the sand, by the admixture of the lime, the sand seems only to render the composition harder, by itself being a harder body; for the best sand, being small fragments of flint, crystal, quartz, &c. is much harder than any body we know of, that can be formed of lime only; and which, in paste, is to be considered as a cement to the harder materials, and therefore composes a harder body; for the same reason that, if we had nothing naturally, but lime as a cement, and should build a

\* The following composition I directed to be used in building the first Lock upon the River Calde., in the year 1760; and which I lately transcribed from the Memorandum Book of Mr. JOSEPH NICKALLS, Civil Engineer, at that time resident Surveyor of the River Calde.

For Face Mortar, Barrow Lime	—	—	measures	4
Ground Minion	—	—	—	2
Coarse Sand	—	—	—	2
Fine Sand	—	—	—	2

And for the rubble backing; to the above composition, add eight measures of small gravel, or pebbles, the largest not larger than a horse-bean; which application of Pebbles was taken from what I observed at *Corf Castle*, § 114.

† This stone was picked up in the high part of the country, in the beaten track of a moor called *Woolley Edge*, not far west of the direct road between *Wakefield* and *Barnsley* in *Yorkshire*; and where a number of stones of the same kind may be found; but yet it would be attended with some trouble to gather a cart load of it.

‡ My experiments were upon Water limestones; but according to the experiments of the Bishop of *Landaff*, upon various kinds of common limestone, it did not appear with certainty to have shrunk at all. See *Watson's Chemical Essays*, vol. ii. page 230.

§ Two measures of Water Lime in powder, will produce nearly one measure of paste; and this, with one measure of *tarras* or *puzzolana*, will produce nearly 1  $\frac{1}{2}$  measure of mortar.

wall with flints, crystals, or rough stones cemented therewith, this wall would be far harder than if built with lime alone.

217. THE experience of ages has shewn, that a considerable quantity of sand and other matter may be introduced with advantage in the making of mortar; but the proportion has never been agreed in: yet from common experience it appears, that there is scarcely any lime, but what, if well burnt and beaten, a load, or measure of lime, will take two loads or measures of sand; that is, the quantity of sand that can be introduced into its composition may be equal to the lime in powder: and consequently if, as in tarras mortar, one measure of tarras is sufficient to give to two measures of slaked lime a sufficient indurating property, to make the composition acquire the proposed degree of hardness under water; then if another measure of clean sand is added, this will only give to the lime that quantity of the harder material that it would bear for building in the air; and this without hurting its cementing property in water; for as the sand can hardly be supposed to act on either material, so as to alter their chymical action on one another; it will, at the same time that it increases the bulk of the whole to half as much more, be cemented together by the other ingredients, and make (for the same reasons as in dry work) a harder composition.—Thus far we are warranted to proceed from the common practice; and as this increases the quantity, that would result from the common tarras composition, in proportion of 2 to 3, I was therefore willing to try this matter further. Thus,

A composition of this kind is further increased in bulk, by another measure of sand; so that one cube foot or measure of the common tarras mortar composition will by this means become two, and quite as good in every respect.—Finding this idea so far to answer, not only in experiment, but my expectations satisfied in works at large, I was induced to try whether lime would not bear a still greater addition of sand; and I soon found that it would, with good beating, take in, for every two measures of slaked lime, one measure of tarras, and three of clean sand; which would produce nearly  $3\frac{1}{2}$  measures of good water mortar, or full  $2\frac{1}{2}$  times the common quantity of mortar from the same quantity of tarras and lime; this being near upon four times the bulk in solid mortar, of the unquenched lime, or the unburnt stone.

218. STILL pursuing the same line of experiment, to see how far this matter could be carried, it appeared that even yet a greater proportion of sand might be introduced; but to bring it to a proper consistence and toughness, so as to be a good cement to large stones, I found it needed so much more beating, that the labour became, in most cases, of more value than the saving of materials\*.—Thus far I had proceeded in the reduction of the expence of Face mortar;

\* This last proportion of lime to sand (allowing for the tarras, which does not appear to me to make so great an increase of bulk as is made by common sand) nearly agrees with the greatest mixture of sand with lime in the experiments of Dr. HIGGINS; see *Calcareous Cements*, page 48; wherein No. 5, contains a mixture of lime to sand as 1 to 8; yet as this is expressly by weight, and as the weight of Thames sand is nearly 4½ times the weight of such common lime as I have tried, bulk for bulk, this will not amount to the full proportion of two measures of sand to one of lime in powder: and though the Doctor says that this "Specimen was not sufficiently plastic for common use, or, as the workmen express themselves, it was too short;" yet as his experiments seem, in a great measure, to turn upon the method of compounding calcareous cements for dry work; where they are continually in a state of moisture, this objection will not apply: besides, it appears VIRRAVIUS allowed two measures of sea or river sand to one of lime, and three of pit sand to the same quantity of lime; and that he means Lime in the Powder is plain, because he says expressly, the lime when quenched is mixed in the proportion of one to three of sand, as judiciously pointed out to me by Mr. NEWTON, who has translated that ancient author. That VIRRAVIUS was not only a judicious, but a practical observer, as well in regard to Mortar, as other articles of building, appears from the distinction he makes betwixt Sharp River sand, and Pit Sand which is generally soft; for of river sand he allows but two to one of lime: and I have long since found the necessity of forming a composition of fine and coarse sand for mortar, unless the sand is naturally so mixed; as appears by the first note on § 214; for, as the lime will receive the most sand in that way, without losing its plasticity, it will of consequence make the hardest and firmest mortar. My practice has uniformly been, if there was plenty of one sort of sand, and a scarcity of the other, to make the mixture, by allowing of the most plentiful sort as far as the proportion of 2 to 1. Dr. HIGGINS not only recommends a mixture of fine and coarse sands, but attempts to fix the best proportion. *Calcareous Cements*, § 12, beginning page 78. See also VIRRAVIUS, B. II. Ch. IV. V. and VI.

It may be of use, and not out of place, here to observe, that, so far as I know, it is a peculiarity of this gentleman to fix the proportion of the ingredients for making mortar by weight. I doubt not, but it answered his end best, in point of accuracy in Experiment; as he had the management of the preparation of the lime himself, but I apprehend this mode will by no means fit the practical builder; for, as the Doctor has fully shewn, that limes not thoroughly burnt, are considerably the heaviest; it will follow that, by weight, the workman when the lime was bad in quality, would also get the least of it; and I have in reality known instances where the proportions given by Dr. HIGGINS (though clearly enough expressed to be weights) were applied as measures; compounding seven bushels of sand with one of lime!

but as common lime, burnt from a pure limestone, either hard or soft, with an admixture of sand only, will never acquire a stony hardness under water, by any treatment I could give it\*; and as this is what is generally made use of in the back part of the walls, even of works intended to be of the best sort, I was very desirous to provide a kind of mortar that might not be too expensive, and yet might internally acquire a stony hardness. Instead therefore of Tarras or Puzzolana, I substituted an equal quantity of Minion; and as the back part of the walls (or backing, as it was called) of the Calder works was in general done with Rubble, (or rough stone from the quarries) where the interstices were large and open, and required a good deal of matter to fill them full, I used the composition already specified, with common lime, taking care to screen the pebbles clean from sand and dirt†; so that the whole composition would be again increased in a greater proportion than that of one to two: we now therefore from every measure of unslaked lime and a measure of minion, together with the sand specified, obtained five measures of backing, or (as we called it) Pebble Mortar.—Where minion is not to be had, as a substitute, if one half, or even one third of its quantity, of tarras or puzzolana is given instead of it, it will answer nearly as good an end, as a whole measure of minion.

219. HAVING thus ascertained the leading facts with respect to the making a composition of water mortar for various uses, it remains a curious question, which being myself unable to resolve, I must leave to the learned Naturalist and Chemist, why an intimate mixture of clay in the composition of limestone of any kind, either hard or soft, should render it capable of setting in water, in a manner that no pure lime I have yet seen from any kind of stone whatsoever, has been capable of doing. It is easy to add Clay in any proportion to a pure lime; but it produces no such effect‡: it is easy to add Brickdust, either finely or coarsely powdered, to such lime, in any proportion, also; but this seems unattended with any other effect than what arises from other bodies that by passing the fire become porous and spongy, and thereby absorbents of water, as already hinted; and excepting what may reasonably be attributed to the iron particles that red brickdust may contain. In short, I have as yet found no treatment of pure calcareous lime, that rendered it more fit to set in Water than it is by nature, except what is to be derived from the admixture of Tarras, Puzzolana, or some ferruginous substance of a similar nature§.

\* Having had the opportunity of taking up a large flat stone, of a close grain, of about five feet square, that had probably lain above a Century at the bottom of a malt cistern, I found it had been well bedded in mortar, which had become conglutinated to the consistence of cheese; but having never come to a perfect dryness, it so far retained its natural humidity, that I found it might, with some pains, be beaten up to mortar, without any addition of water; and afterwards, being suffered to dry in the air, it set to a stony hardness, and appeared as good mortar for dry work, as any which that part of the country produced.

† See the first note on § 214.

‡ In the year 1760, having some buildings to make for myself in a part of the country where the limestone is of the more pure kind, and the lime tender and light coloured, I resolved to try an experiment upon a considerable scale. I dissolved clay of the yellow kind (which, when burnt, makes a good hard red brick) in water, in such proportion, as that this water being made use of in wetting the quick lime to make it into mortar, it would have somewhat less than the quantity I had generally found in the blue Lias limes. I at first imagined I had made a valuable acquisition, as the mortar, that from its situation was to become dry, set very well; but some of this clay mortar being used where it was likely to continue long in a humid state, though not actually exposed to water, I found it to set very tardily; inasmuch that at the end of three months, I could make an impression upon it with my fingers: however, after a twelvemonth it was tolerably hard; but on examining the building so done in the year 1786, I found all the dry work not so hard as the mortar of the same lime without clay. Some parts of both had equally perished, and that in the humid place had acquired but a very moderate degree of hardness: it was not in reality, as I judge, near so hard as the same mortar would have been, if no clay had been introduced; but here no common mortar had been used to compare it with.

§ Some years ago M. LORION published a treatise upon the composition of Ancient Cements, with a view to improve the modern. He seems to suppose the grand secret that has been lost, to consist in the admixture of a certain quantity of the burnt limestone unslaked, and ground to a powder, with lime wetted up in large heaps for use, as in the common method for large buildings.—I have made trial of this method, both in small and in large; for, however little of likelihood of advantage a proposition may contain, yet when this concerns a physical process, nothing can be safely concluded, but from actual trial. And I must candidly own, that the effect was better than I had expected; for I found the composition not only set more readily than mortar, as commonly made up, but much less liable to crack; and consequently, if this cement was made use of in water building, it was less apt to re-dissolve, because, it would more speedily get set to a firmer consistence, and so as more ably to resist the water from entering its pores; but when the water was brought upon it, in whatever state of hardness it was at the time, it at best but remained in that state, without any further induration, while the water remained upon it; and, as I expect, would so remain, till it had had some opportunity of acquiring hardness by further drying.—M. LORION, I perceive, strongly recommends, where water is concerned, the use of smiths forge scales, and the refuse of iron to be joined with his composition; but this I apprehend is no new discovery of M. LORION's, as these substances have been long known to produce a good effect upon all kinds of lime for water building. But after all the experiments I have made, it yet remains



220. NOTHING more directly conduces to the perfection of water mortar, than a means of doing the work with very moderate quantities of it. For these purposes, it is a first principle, that all must be filled full: but the more stone there is used in a cube yard of masonry, the less room there will be for mortar. I have already described the methods I made use of in reducing the quantity of the more valuable materials composing the mortar for the Calder navigation, where the ashler walls were backed, as is generally the practice, with rubble stone, or with bricks; but when we came to the upper part of that navigation, in the neighbourhood of Cromwell Bottom and Elland Edge, being there supplied with a species of stone that naturally rises in flat beds, or that can easily be split to any thickness from two feet to two inches; I found a great utility arise from the particular texture of this stone, not only in composing the ashler part, (which scarcely needed any hewing, except a little regulation of the faces and end joints) but also in the backing; for the stones intended for this use being sorted, and suited together, so as to form the internal or backing courses of an uniform thickness, we were enabled to lay the pieces together, in the manner of a promiscuous pavement; and these being laid down upon a bed of mortar, and the interstices afterwards made good with small rubble work, to bring to a level and complete the courses; by these means we were enabled not only to preserve a firm bond throughout, but to use very little mortar in proportion to what we had been accustomed to do in common rubble.

221. MY mind had long dwelt upon this idea, without having afterwards an opportunity of putting it in practice; no quarries affording flat bedded stones having occurred in the proximity of any of my future works; the occasion was therefore reserved to my being joined in consultation with the Gentlemen Engineers at Portsmouth, as already mentioned; when those gentlemen observing the moderate price at which they obtained not only flat backing, but Furbeck ashler in rough courses, from those quarries, the application in the way above mentioned immediately presented itself; and those gentlemen being very attentive to all improvements in the building art, we soon found by proper estimation, that walls might be built with this kind of stone upon this principle, and especially with the use of a mortar also investigated for that purpose, as already mentioned, not only at a less price than walls backed with common brick and tarras, but of superior bond and solidity\* to any thing that has yet been done, except with block stone hewn within and without.

I need not acquaint the ingenious artist, that more or less mortar will be consumed, in proportion as the flat pieces which compose the backing are larger, and brought more closely together in the first instance: but it may be agreeable to him to be informed, that if the stones are tolerably bedded, a little work of the hammer will bring them so close together, that four cube feet of mortar will be sufficient to complete a cube yard of backing.

222. BY way of recapitulation and sum of what I have said upon the article of Water Cement, I here subjoin a Table, containing a specimen of twenty different compositions, most of which I have used in different situations, and for different purposes.

a doubt with me, whether, be it for dry works or water works, the use of fresh slaked lime, of whatever kind, as recommended by Dr. HIGGINS, is not preferable to the same kind of lime treated in M. LORIOR's way. This I am sure of, that the method of the former gentleman is attended with less trouble and expence, as not requiring any part of the materials to be ground in a mill, or otherwise pulverized.—Water Lime, ever since I found out the distinction, I have always used as fresh as possible, as I was instructed at Watchet; but in the use of common lime, especially for dry works, I had nearly fallen into the common method of wetting it up, till I read M. LORIOR and Dr. HIGGINS.

\* Report of Colonel PHIPPS, Lieutenant Colonel MONCRIEF, Captain TWISS of his Majesty's Corps of Engineers, and JOHN SKEATON, Civil Engineer.

A TABLE containing Twenty Compositions of Water Mortar, suited to different Situations and Circumstances.

No.	Water Lime with Puzzolana.	Lime Powder.	Puzzolana.	Common Sand.	No. of Cube Feet.	Expence per Cube Foot.	
		Bushels.	Bushels.	Bushels.		s.	d.
1	Edystone Mortar . . . . .	2	2	—	2.32	3	8
2	Stone Mortar . . . . .	2	1	1	2.68	2	1½
3	— 2d Sort . . . . .	2	1	2	3.57	1	7½
4	Face Mortar . . . . .	2	1	3	4.67	1	4
5	— 2d Sort . . . . .	2	0½	3	4.17	1	1
6	Backing Mortar . . . . .	2	0½	3	4.04	0	11
Water Lime with Minion.			Minion.				
7	Face Mortar . . . . .	2	2	1	3.22	1	5½
8	— Calder Composition . . . . .	2	1	2	3.57	1	1
9	Backing Mortar . . . . .	2	0½	3	4.17	0	10
10	— 2d Sort . . . . .	2	0½	3	4.04	0	9½
Common Lime with Tarras.			Tarras.				
11	Tarras Mortar . . . . .	2	1	—	1.67	4	0
12	— increased . . . . .	2	1	1	2.50	2	9
13	— further . . . . .	2	1	2	3.45	2	0½
14	— still further . . . . .	2	1	3	4.35	1	8
15	Tarras Backing Mortar . . . . .	2	0½	3	3.50	1	2½
16	— 2d Sort . . . . .	2	0½	3	3.37	0	11½
Common Lime with Minion.			Minion.				
17	Ordinary Face Mortar . . . . .	2	2	2	2.75	1	5½
18	— 2d Sort . . . . .	2	1	3	4.34	0	8½
19	Ordinary Backing Mortar . . . . .	2	0½	3	4.05	0	8
20	— 2d Sort . . . . .	2	0½	3	3.92	0	7½

## OBSERVATIONS ON THE PRECEDING TABLE.

1st. Those that would make mortar according to the preceding Table, should know, that the materials are all supposed to be in a dry state when measured.

2d. That the lime is supposed to be thrown into the measure with a shovel, with some degree of force; for if put in as light as possible, in the way to make the most measure of it, there will be a want of the real quantity; and if pressed down, the measure will contain considerably more than what can be expected in purchasing the material: and the same may be said of the puzzolana, the tarras, and the minion.

3d. Respecting sand, it is particularly to be noted, that if in a moist state, the real quantity is considerably less under the same measure, than if dry, and that in an uncertain degree: and as moist sand is most frequently brought for use, it is advisable that the operator should take a means of finding the difference of the proportion, and allowing accordingly in measure.

4th. I would also observe, that, if the sand is not naturally a composition of fine and coarse,

it should be rendered so by an admixture of different sorts; the proportion of one to the other need not be much studied; what I have already said in note \* on § 218. will be a sufficient direction.

5th. The due beating of the mortar is however of great consequence; and, without going into that repetition of beating, which has been always looked on as essential to the making the common tarras mortar, such as No. 11, a degree of beating sufficient to give it all possible consistence and toughness, before it is used, is in reality indispensable: and the method that I have found to answer the end in the most satisfactory way is, to mix the due proportion of the lime and the puzzolana, the tarras, or the minion, together in the dry powder; and it will also be well, to have at least one third of the sand (either fine or coarse) likewise dry: put as much water to the lime, as that with a shovel or beater you can bring it to a paste of a moderate consistence, but rather more wet than to be properly used as mortar in that state; then by degrees beat in the moist sand, and afterwards the dry, bringing it to a consistence by beating after every addition. The dry sand is intended to take up the superfluous moisture, so as to render the mortar immediately fit for use; and if this has not brought it to a sufficient stiffness, you may let it lie till it inclines to set, and then beat it up to the due consistence; or, if immediately wanted, you may beat in a little dry lime powder to drink up the superfluous moisture; always, however, faithfully remembering not to terminate the beating, till the mass has got all the toughness that you find it will acquire by beating. This method fully answers where Water Lime is concerned.

6th. The customary allowance for tarras mortar beating, first and last, is a day's work of a man for every bushel of tarras; that is, for two bushels of lime powder with one bushel of tarras; so that, by No. 11, if a labourer's day's work (as at London) is rated at 2s. then (the bushel of tarras being valued at 4s.) the beating will be half the price of the tarras; and the mortar produced being only  $1\frac{1}{2}$  cube feet, the beating of the mortar will therefore amount to  $14\frac{1}{2}d.$  per cube foot: whereas, in the way I have just mentioned, a man in half a day will beat to a very good consistence the whole produce that can be made, in any of the articles, from two bushels of Lime; so that the beating of the best face mortar, as No. 4, being  $4\frac{1}{2}$  cube feet, will be done for less than  $2\frac{1}{2}d.$  at the same rate of labour.

7th. In regard to the column of prices, they can only be considered as comparative: the articles of carriage, dearthness of particular materials and labour, will greatly vary in different situations; but the prices being given as under, at which the different ingredients are rated in the preceding table, the ingenious artist will be at no loss either to compare the different compositions with one another; or find the value of them in his own situation; or vary them to suit his price and purpose\*.

	s. d.
Water lime per bushel in the dry powder . . . . .	0 9
Common lime ditto . . . . .	0 4
Puzzolana in powder, prepared . . . . .	3 0
Tarras ditto . . . . .	4 0
Minion ditto . . . . .	1 0
Coarse or fine sand, or mixed . . . . .	0 2
† The labour of beating two bushels of common lime to tarras mortar, is supposed	2 0
The labour of beating two bushels of water lime for those articles . . . . .	1 0

\* There are many customary measures and ways of measuring amongst workmen, as well as in different counties: when I speak of a Bushel, I would be understood to mean the Winchester Corn Bushel striked, or the contents reduced to a level with the border.

I also suppose the forge scales of iron (when equally powdered, and sifted clean from dirt and glassy slagg) to be equivalent to as much puzzolana or tarras: rust of iron, or iron ore burnt, powdered, and sifted, to be equivalent to minion; and each of these to about half the quantity of puzzolana or tarras: but as the materials themselves may differ, I would advise the curious artist to be attentive to the result of his own trials.—N. B. I suppose No. 5 equal in firmness and validity to No. 11; and No. 10 to No. 13.

† This article of labour is only applied in No. 11, 12, 13, and 14.



## BOOK IV.

AN ACCOUNT OF PROCEEDINGS IN THE CONSTRUCTION OF THE STONE-  
WORK, &c. UPON THE ROCK, FROM THE BEGINNING TO THE  
FINISHING OF THE BUILDING. WITH AFTER  
OCCURRENCES.

## CHAP. I.

CONTAINING AN ACCOUNT OF THE FIRST YEAR'S BUILDING UPON THE  
ROCK.

223. **BY** the end of May 1757, we had got every thing in readiness to carry out the Neptune Buss and begin the Work; it was however the 3d of June before wind and weather suited for our getting under way. On that day, being accompanied by Mr. JESSOP, eight seamen, the mould-maker, two moorstone masons, and six tinnerns, we sailed out of Plymouth Sound; but it falling calm, we came to an anchor about a league from the rock; and the next morning proving favourable, at six we laid hold of the ring of the buoy. We proceeded to heave up the moorings by means of our great tackle blocks, and could we have proceeded at the rate we began, we should have had them up in an hour; but the links of the buoy chain having been made each six inches in length, by way of getting faster forward with the work in making, we found, when these links came to a considerable strain upon the davit roll, which was of cast iron, and (as mentioned § 143.) not above nine or ten inches in diameter, they began to bend upon the convexity of the roll; and as I was apprehensive of the ill consequence that might attend their breaking, the following remedy occurred to me: I ordered the carpenter to cut some trenails into short pieces, of about three inches long, and to split each length into two; and those pieces being applied betwixt the chain and the roll at the flexure of each link, as it came to a bearing, prevented the middle part of each link from touching the roll, and therefore its straightness and figure could no way be changed by the strain in passing over the roll; and the pieces delivering themselves as the chain cleared the roll, they would serve the same purpose many times over.

The appearance of caution begets an idea of danger to those who otherwise never would have had any apprehension of it; and though the risk of failure was lessened in a great degree by the proposed application, as was confessed by the whole company, yet it was observed, that if the chain should break any where between the roll and the tackle, the person that applied the pieces of wood would be in danger of being cut in two by the chain, or carried overboard along with it. This being the sense of my ship-mates, and as I always made it a rule not to put another upon doing what I was afraid to do myself, the Post of Honour naturally devolved on me; I therefore attended the getting in of the remainder of the eleven fathoms of chain, link by link, till we came to the great swivel of the bridle chain; and though this of course took some time, and left room for serious pause, yet the consideration of having previously tried the chain by a far greater strain than it was ever destined to bear, (see § 156.) prevented those reflections from being uneasy.—This business having been successfully executed, and our addition of five fathoms of large chain applied to the bridle, (see § 183.) at twelve o'clock this day, the 4th of June, we found ourselves once more riding as safely and securely at our moorings as we did the last season.

224. THE weather did not admit of our landing that afternoon; but the next morning at eleven we landed, and immediately proceeded with fixing the Fender Piles on the east side of the rock, which were intended to prevent the boats from rubbing against it, according to the idea given thereof, § 99. and as shewn in the elevation of the east side of the rock in Plate No. 14. We also proceeded in fixing up the shears and the windlass, as shewn in the same plate; and though we made a considerable progress the same tide, which lasted till four o'clock, yet from the usual uncertainty of weather, even in the best of every season, it was the 10th of June before those necessary matters were dispatched; inclusive of the mooring the Transport Buoy, at eighty fathoms north of the landing-place\*, in fourteen fathom water†.—By way of seeing that all our tackle acted properly, and as some trial of its sufficiency, we hoisted the Sea-Horse yawl, a strong heavy ship's long-boat, with several people in it, upon the top of the rock; and finding every thing to act properly and to be sufficiently manageable, we were now ready for receiving the stone; and the whole company returned home in the yawl, except such hands as were necessarily left to take care of the buss.

225. ON Saturday the 11th of June the first course of stone was put on board the Edystone boat, (see Plate No. 10. Fig. 1.) with all the necessary stores, tools, and utensils; and having appointed Mr. JESSOP, at his own request, to be a foreman in the place of HILL, discharged, I took on this occasion both the foremen, Messrs. JESSOP and RICHARDSON, along with me, as also the necessary hands. We landed at eight on Sunday morning the 12th of June, and before noon had got the first stone into its place, being that upon which the date of the year 1757 is inscribed in deep characters‡; and the tide coming upon us, we secured it with chains to the old stanchions, and then quitted the rock till the evening tide, when it was fitted, bedded in mortar, trenailed down, and completely fixed; and all the outward joints coated over with Plaster of Paris, to prevent the immediate wash of the sea upon the mortar, (see § 190). This stone, according to its dimensions, weighed 2½ tons.—The weather serving at intervals, it was at the evening of Monday the 13th that the first course, consisting of four stones, was finished; and which, as they all presented some part of their faces to the sea, were all of Moorstone.

226. THE next day, Tuesday the 14th, the second course, see Plate No. 10. Fig. 2. arrived; and some of it was immediately landed, proceeded with, and in part set the same tide: the loose pieces being chained together by strong chains, made on purpose for this use, and those ultimately to the stanchions; or to Lewises in the holes of the work of Course I. that had already been fixed.—The sea was uncommonly smooth when we got upon the rock, this evening's tide; but while we were proceeding with our work, within the space of an hour and half, the wind sprung up at N. E. and blew so fresh, that the Weston, lying to deliver the remainder of her cargo, had some difficulty in getting out of the Gut; and had it not been for the transport buoy, to which she had a fastening by a rope, it would probably have proved impracticable to have got her out again. And we soon saw it was necessary to get every thing in the best posture, time and circumstances would admit, in order to quit the rock, with safety to ourselves, and security to what we must necessarily leave behind us.

The pieces that were fixed and trenailed down, were supposed to be proof against whatever might happen; but the loose pieces, and those that were simply lowered down into their dovetail recesses, were considered as needing some additional security to prevent their being carried away by the violence of the sea. Of the thirteen pieces of which Course II. consisted, five only were landed: No. 1. was completely set; N° 2 and 3 were lowered into their places, and secured by chains; and 4 and 5, which lay at the top of the rock, were chained together, and also to the slide-ladder, which was very strongly lashed down to eye-bolts, purposely fixed on the rock

\* This was the great buoy that had rode at the moorings during the winter, and was moored by the same chain to which it had been fastened during that season: but for this service it had been sent home and repaired, and was attached to an old anchor of 12 cwt.

† See § 102, and Plate No. 8.

‡ To facilitate the work of getting down the stones, after they were landed upon the top of the rock, a kind of frame, something in form of a ladder, was lashed upon its inclining surface, upon which we slid the stones to their respective places.

for that intent.—Every moment the wind and sea so increased, that it was with the utmost difficulty our two yawls could be prevented from being staved upon the rock; and while we were endeavouring to get our tackle-blocks, mortar-buckets, and a great variety of loose materials and tools, on board the yawls, and to preserve our utensils and stores; we were risking the chance, whether we ourselves should not be left behind to be washed off the rock. Our light setting Triangle\*, by which we hoisted and lowered the pieces of stone into their places, as being our greatest incumbrance, was also lashed to the slide-ladder.—Having at last got into our yawls, the wind and sea were so increased from the N. E. quarter, that we found it quite impracticable to make head against it, so as to row out of the Gut to the northward; we therefore had no alternative, but, compelled by necessity, we risked our passage through the rocks to the southward, aiming at the interval betwixt the Sugar Loaf and the House Reef, (see Plate No. 3.) and both boats providentially got through unhurt. We then, having doubled the south point of the House Reef, had to make our way to the north, by the west side thereof; which, as it was not quite low water at the rocks, afforded us some tolerable shelter, and gave us time to consult what to do: for, as the current of the channel tide was then setting strongly to the westward, and as our buss lay to the N. E. of the rocks, and of course right to windward, there seemed a necessity for our utmost exertions to recover the buss. We therefore agreed that the light yawl should row the headmost, taking the other in tow; by which means our united strength could be equally exerted for the benefit of the whole.—Accordingly, when by rowing north we had cleared the House Reef, we soon got into so much wind, sea, and current of tide, that we found, notwithstanding our joint efforts to get to the eastward, we were gradually carried to the west; and, after a struggle of an hour and an half in this way, we found it quite impracticable for both boats to get on board the buss. Each boat rowed with four oars; Messrs. SMEATON and JESSOP, with two seamen, and four other hands, were in the light yawl, and Mr. RICHARDSON, one of our best seamen, and eight other hands, were in the Sea-Horse; which was to make her way westward to the floating Light, that lay to leeward (see § 138): and we in the light yawl determined to endeavour to gain the buss; and if that could not be effected, also to bear away towards the other vessel.

After labouring at our oars for an hour and an half more, we recovered the buss, (which lay not much more than 200 fathoms from the place where we parted with the Sea-Horse) to the great joy of ourselves, and anxiety for our associates, it then blowing a hard gale of wind, which continued increasing all night.

About four the next morning the wind shifted to the S. E. which produced so troublesome a sea, that the Weston, which had rode at the transport buoy all night, made signals of distress; and was therefore ordered to slip and make her best port. In the afternoon the wind coming to S. with the tide of flood, the Sea-Horse returned to the buss with all hands in safety, with grateful hearts for the kind treatment they had received on board the floating light, and for their deliverance; having found the utmost difficulty and danger in getting aboard the floating light, on account of the sea's running so high.

227. IN the evening we made a short tide upon the rock, and had the satisfaction to find that no material damage had happened to any thing; we therefore proceeded with our work, and completely fixed No. 2. of Course II: and next morning, Thursday June the 16th the Weston returning from Plymouth, came to the transport buoy. We then proceeded both morning and evening tides, though they were not very favourable; and this day sent home Mr. JESSOP, to prepare himself and company to relieve Mr. RICHARDSON's; and for a supply of lime and other necessaries, of which we were in want. On the morning of Friday the 17th, we again landed for a short time; and, notwithstanding we did not meet with any thing amiss on our return to the rock on Wednesday evening after the hard gale of wind, yet this morning we found a part of the rock in the border of our work, that secured a corner of No. 3. was gone: we therefore, to secure that stone to its neighbour, applied an iron cramp, of which we had some in readiness in case of accident.—We were prevented landing in the evening by a fresh of wind and rain at

\* This Triangle is represented as standing upon the wall of the building, supposed to be raised above the vaulted covering of the store-room, Plate No. 14.



N. W. but landed again on Saturday morning's tide, the 18th. However we had not been long there before a great swell arose from the S. W. ; and, though there had been no wind apparently to occasion it, yet it came upon us so fast, that we were obliged to quit the rock before we could get our work into so satisfactory a posture of defence as I wished. It was, however, as follows, N° 1, 2, 3, 4, and 5, were completely fixed as intended ; N° 6 and 7 were fitted, and lowered upon their mortar beds ; No. 8 was simply got into its place, with a weight of lead of five cwt. upon it\* ; which, in all such trials as had hitherto been made thereof, had lain quietly. Not having time to get the stone, No. 9, into its place, we chained it upon the top of the rock to the slide-ladder, as we had done before on Tuesday. In this condition we left the rock, having staid till we were all wet from head to foot.—The swell continued the remainder of the day, and the wind freshening at S. W. in the night, at five o'clock on Sunday morning J. BOWDEN made the signal of distress, and was therefore ordered to slip and go into port.

In the afternoon, on tide of flood, the sea frequently broke in a large dense body over the head of the shears, which were twenty-four feet in height above the top of rock, and the seas running very short where we lay, the bowsprit of the buss sometimes dipped in the water.—We could plainly see the stone on the top of the rock till towards the evening, at about high water, when we observed something of timber to have broke loose, and to lie in a wrong situation ; soon after which it disappeared, as also the stone ; so we concluded it was the slide-ladder and the stone that had gone together.—The next morning, Monday the 20th, the wind was rather increased than abated ; but no further alteration was apparent on the rock since the last night.—Towards evening the wind veered to the south, and blew a storm till three o'clock on Tuesday morning, when it began to abate. About nine o'clock it became more moderate ; and finding that bread was running short among the workmen, as we were not likely very soon to get to work again, I dispatched the greatest part of them home in the Sea-Horse yawl : and about twelve o'clock the wind and sea having become still more moderate, I judged it practicable to row a-head against it, so as to get to the westward of the rock, and reconnoitre our damages : accordingly, taking four oars in the light yawl, it being then near low water, I observed, when the sea fell away from the rocks, (every sea then breaking bodily over it) that No. 9, and the slide-ladder to which it was chained, were both gone ; that the two pieces of moorstone N° 5 and 6, which had only been let down upon their mortar beds without further fastening, were also gone ; that No. 3 had broke its cramp and was gone ; and that the 5 cwt. that had been laid upon the most projecting part of the piece No. 8, had, by the force of the sea acting edgewise upon it, been driven to the eastward till it was stopped by the rise of the third step, against which it seemed abutted ; so that having thereby quitted the piece No. 8, upon which it was laid, that was gone also : we therefore, as it appeared, had lost five pieces of stone ; the loss of which was in the first instance alleviated, by finding that the first course appeared so thoroughly united with the rock, that its surface begun to look black with dark-coloured moss fixing upon it, and giving it the same hue as the rock itself : also, that our shears and windlass were all standing without the least derangement.

I did not wait for the subsiding of the winds and seas, so as to enable us to land, and look out whether or no we could recover any of the lost pieces ; I immediately made for Plymouth in the light yawl, and landed at Mill Bay at five o'clock on Tuesday evening the 21st ; and, having collected the moulds of the stones we had lost, and chosen proper spare blocks, I set a couple of men to work upon each piece of stone, day and night, till finished.—This disaster, though it furnished a few reflections, yet they were not of the unpleasant kind ; for, as every part of the stonework, that was completed according to its original intention, appeared to have remained fixed, it demonstrated the practicability of the method chosen ; and at the same time shewed the preference of wedging to cramping, as the cramp had failed : and also the utility of trenails† as a security till the mortar was become hard.

\* This weight, which was in the shape of the segment of a sphere, I had got prepared, as a means of holding down such stones as were simply lowered into their recesses, and which for want of time could not be got fixed in a more effectual manner ; for, from the figure thereof, its base or flat side being laid upon the flat surface of the stone, the action of the sea could have very little hold upon it, being all a smooth surface, the ring excepted.

† The method of trenailing and wedging will be fully described in its due place.

In less than two days the five pieces of stone were completed; and on Thursday the 23d in the evening I went on board the *Weston* with the stones, carrying also Mr. JESSOP and company; but there being little wind, we were obliged to row all night; and when, by this labour, we had got within a league of the buss, it began to blow so hard at E. that we thought it advisable to bear away for some western port. Accordingly at seven in the morning we came to an anchor in Fowey harbour; and that day took the opportunity of viewing the progress of our moorstone works at Lanlivery. The wind continued fresh at E. the next day; and as the day after, being Saturday the 25th, it again became RICHARDSON's turn to go out, I ordered BOWDEN to beat to windward, if possible, and get to his moorings at the transport buoy, as soon as he could; and with Mr. JESSOP and his company, returned over land to Plymouth.

228. AT four o'clock on Monday morning the 27th, the weather serving, I went out with RICHARDSON and company, in the *Edystone* boat; we got to the buss at ten, and found the *Weston* at the transport buoy, but could not land till the afternoon's tide, being a complete week since we had been last upon the rock. We first replaced the ladder, and afterwards proceeded, without more than usual interruptions, till the 30th in the evening, when we closed and completed the Course No. II. and began upon Course III.—The execution of these two courses had taken us up from the 12th to the 30th inclusive, and though they consisted of no more than seventeen pieces of stone in the whole, yet I found myself no ways disheartened; for, in establishing these two courses, I considered the most difficult and arduous part of the work to be already accomplished, as these two courses brought us up to the same level where my predecessor Mr. RUDYERD had begun.

While the new stones of Course II. were making, I received intelligence from the buss, that the seamen there, during our absence, had been into the Gut, and had observed some of the pieces we had lost to be lying in the bottom of it: I therefore, besides forming new pieces, ordered an utensil to be made, by means of which it seemed likely I might get some of these pieces up again: and though all the new stones were landed and set in their places before I had an opportunity of trying the tool; yet I was willing to convince myself, how far it might be useful upon any future similar occasion.—Accordingly, between the tides of the 30th, (the water falling away so as to leave only ten feet depth in the Gut) I made a trial of the instrument\*, where-with I succeeded in getting up one of the stones, which proved to be No. 9, that was chained to the ladder at the top of the rock; and I might have got up two others that lay there, had they been wanted; but the mere recovery of stones, after a sufficient experiment had been made, was scarcely worth the time.

The next day, Friday July the 1st, we were able to land; but as the wind blew fresh at S. W. I judged it unsafe to bring the *Edystone* boat into the Gut to deliver any stone. I observed, that during the last tide, the swell had washed some of the pointing out of the exterior joints, and also some of the grouting out of the upright joints; but as a heavy sea seemed likely to come on with the tide of flood, I judged it to be to no purpose to repair the cement while a violent swell continued; I therefore employed the company in cutting off the iron stanchions belonging to the former building, as they now began to be in our way, and as the hold we got of them ceased to be of use, in proportion as we got more fastening from the lewis holes of our own work.—It was not long before the master of the *Edystone* boat gave warning, he could lie no longer at the transport buoy; I therefore took my passage on board of it to Plymouth, and landed in the afternoon.

229. THE weather having become more favourable, on Sunday morning the 3d of July, I went on board, accompanied by Mr. JESSOP, and his party, to whom, as they had never had the opportunity of setting a stone, it behoved me to attend. We however not only met with a repulse this day, but could not make any further attempt to go out till Tuesday the 5th; and then the wind, though gentle, being contrary, had not the company on board the buss come with their two yawls and towed us thither, in all probability the day would have been spent in fruitless

\* See the explanation of this instrument, amongst the tools and utensils contrived or adapted to the *Edystone* works, in Plate No. 13.

attempts. Our difficulty was considerably increased by the coming on of so thick a fog, that all our efforts united, we had much ado to regain the buss.—*RICHARDSON* told me they had had such bad weather, that the slide-ladder had again broke its lashings and driven away; that they had however got all the irons cut off close to the rock; but that the last tide, though there was only a breeze at S. W. the swell was so great, and came on so suddenly, as to put them in great danger of being washed off from the top of the rock, before they could quit it.

At two o'clock this day we landed, and *JESSOP*'s company set six pieces of stone, and effectually repaired the cement; and next day a proportionable dispatch was made, though the weather was not very mild.—In the night, betwixt eleven and twelve o'clock, the watch upon deck espied a sail upon the rocks; whereupon we immediately sent one of our yawls to her relief; which soon returned with the whole crew, several of whom were in their shirts, and in great distress. They informed us that the vessel was the *Charming Sally* of Biddeford, a snow of 130 tons burthen. They had been at Dartmouth, from whence they were returning in ballast; and as there was no stress of weather at that time to drive them upon the rocks, we could not but wonder how they had contrived to get thither: we were informed, that not knowing exactly where they were, they took the rocks to be so many fishing boats, till it was too late to clear them: and that on the vessel's striking, she filled so quick that the boat floated upon the deck before they could get into it. In steering westward, she had cleared the south point of the south-east reef, and fell upon the south reef near the highest part. See Plate No. 3.—The vessel sat almost upright upon the rocks, and the masts remained standing the whole of the day; but in the night following she was wholly beaten to pieces.—Her crew, consisting of seven hands, having been refreshed on board the buss, the next day rowed off in their boat to Looe; and as we had not landed since the 8th, nor now more likely, I took the opportunity of returning to Plymouth in a Cawsand fisherman, who came with an intent to pick up something from the wreck; in which however he was disappointed.

230. ON Monday the 11th I again went out with *RICHARDSON* and company; Course III. consisting of twenty-five pieces, was closed on the following day, and Course IV. begun.—The tide of the 13th in the evening was remarkably quiet, and allowed us to go on with our work uninterruptedly; but just after we had got on board the buss, a sudden squall of wind arose from the S. W. which at once threatened a most dreadful storm; and it blew so hard, that we expected the mast to go by the board; but before the necessary orders could be given, by way of preparation, it became a perfect calin; the squall not having continued more than a minute, as it seemed to us. This was followed with a breeze from the east, and frequent flashes of lightning till the tide of ebb.

Thursday the 14th of July the company pursued the work of Course IV; and now both companies being fully instructed in the method of setting the basement courses, I returned to Plymouth; from whence I proposed to visit each company as often as should seem expedient, but always once in each company's turn, if wind and weather should permit.

231. I WENT out with *JESSOP*'s company on Monday the 18th; but we were repulsed by bad weather, which continued to the 23d. The 21st, *RICHARDSON*'s company having almost exhausted their provisions, and not being likely to get any supplies, came home in the *Sea-Horse* yawl: and gave account, that a few days before they came home, in hoisting one of the stones out of the vessel upon the rock, by neglecting to belay the tackle-fall of the out-hawler *Guy*, the shears came down flat upon the rock in the midst of the men, but providentially without doing any harm to either men or shears. He also acquainted me that they had had the greatest swell from the south they ever experienced, and that the 500lb. weight had been washed from the work, but that they had found it entangled in the rocks above low water mark.

About this time I had intelligence from Portland, that two vessels laden with stone for the Edystone, waiting a favourable opportunity to sail for Plymouth, had all their hands pressed by the lieutenant of a tender stationed there; notwithstanding the service they were upon, and their having on that account Admiralty protections. This circumstance would have proved very distressing, had not the Lords of the Admiralty, on application, sent immediate orders, by express, for



discharging the men: and it is a great satisfaction to me when I say, that on this, as well as on every other occasion, we found the Admiralty Board was ready and disposed to give all the furtherance to our work in their power; though we did not always find that countenance from their servants.

232. CONTRARY winds, ground swells, and heavy seas for several days, interrupted the regularity of our proceedings; however, taking such opportunities as we could, the Course No. IV. consisting of twenty-three pieces of stone, was closed, in the morning's tide of the 31st of July, (see Plate No. 10): and in the evening's tide five pieces of Course V. were set.—Our work went on regularly for some days together; and on visiting the work upon the 5th of August, I found the Course No. V. containing twenty-six pieces, closed in, (see Plate No. 10); but that by some inadvertency in proceeding with the interior part, the masons had been obliged to set two of the outside pieces so as to be further out than they should have been by an inch each. However, as I found the work was sound and firm, I thought it better to cut off the superfluous stone from the outside, than to disturb the work by the violence that must have been used in unsettling the pieces; I therefore determined to let them stand as they were, till the cement was become so hard as to support the edges of the stone while the faces were working afresh; and which, from the mortar of our first and second course, we found was likely to be the case before the close of the season.—One of the dovetails had also given way in driving a trenail, owing to a flaw in the stone; for the remedying whereof we applied a cramp.

This day our additional boat, that had for some time been fitting out, called the Assistant, and of which I appointed SAMUEL MEDLING to be master, brought out and landed at the rock her first cargo of stone, containing a part of Course VI. some of which were proceeded with and set: the Edystone boat also arrived with another cargo of lime and puzzolana, as well as stone, and came to the transport buoy; but the wind beginning to blow hard, she was obliged to look out for a harbour.—At this time we were in greater want of lime and Puzzolana, than of stone; and as nothing could proceed without these necessary materials, and it being uncertain when the boat might return, I contrived as follows to get a cask of each on board the buss before she left us.—The sea was so hollow and tumultuous, that though it was practicable for the light yawl to row near enough to throw a small rope on board the boat, yet it was impracticable for the yawl to receive any thing of weight over her side without danger of filling. I therefore ordered W. SMART, the master of the boat, to lash a cask of each to the shrouds with Spun Yarn; so that when the lashing was cut, either of the casks might instantly go overboard. A small rope from the buss having been fixed to each, and the lashings successively cut at a favourable moment, the casks immediately fell into the sea, and were easily towed on board the buss, the materials not suffering any material injury by being wet with sea water: and this expedient proved of the more value, as by this means we proceeded with the work of Course VI. several tides sooner than otherwise we could.

233. THE 8th of August at noon, the weather being exceeding fine, with a low neap tide, I took the opportunity of drawing a meridian line upon the platform of Course VI. the sea never going over the work during the whole tide, which was the first time it had not washed over all, since we began to build: we therefore took this favourable opportunity of carefully making good all our pointings and groutings, wherever the water had washed during the bad weather that had succeeded the last departure of the Edystone boat; and which was the case with it in places where it had not had time, to set before a rough tide came on; but I observed with much satisfaction, that whatever, not only of the original work, but of the repaired pointing, had once stood a rough tide, without giving way, the same place never after failed.—I also observed, that as in mending the pointings we had in some places made trial of Dutch tarras as well as puzzolana, interchangeably, the puzzolana, for hard service, was evidently superior to the tarras: and some particular joints had proved so difficult, that I was obliged to try other expedients; the best of which was to chop Oakum very small, and beat it up along with the mortar. This was our last resource, and it never failed us.

234. ON landing at Mill Bay, the 9th of August, I had the satisfaction to find four vessels

arrived from Portland with some pieces of stone, which their detention had caused us to be much in want of. Upon the 11th I again went out in the vessel that contained the remaining pieces of Course VI; those I saw fixed; and that course, consisting of thirty-two pieces, closed in, the same evening. See Plate No. 10.—This completing our six basement courses, brought our work upon the same level to which we had, the preceding season, reduced the top of the rock; and upon this, as a common base, the rest of the structure was to be raised by regular entire courses.—The time this part of the work (consisting of 123 pieces of stone) had taken up, was from the 12th of June to the 11th of August inclusive, being a space of sixty-one days. We now considered our greatest difficulties to be successfully surmounted, as every succeeding course had given us more and more time, as well as more and more room; and this will appear from our proceedings; for it has already been noticed that the first two courses, consisting of nineteen pieces of stone only, had cost us seventeen days.

235. HAVING now got the work to this desirable situation, I apprehend it will be agreeable to my reader, to be more particularly acquainted with the method in which the stones were set and fixed.—I have intimated § 167, that when each separate piece, of which a course was to consist, was separately wrought, they were all to be brought to their exact places with respect to each other upon the platform in the work-yard, and so marked, that after being numbered and taken to pieces, they could again be restored to the same relative position. This was done upon the complete circular courses by drawing lines from the center to the circumference, passing through the middle of each set of stones; and likewise concentric circles through the middle of each tier or circle of stones, so as to indicate to the eye their relative position to each other: but to render the marks not easily delible, where those lines crossed the joints, a nick was cut and sunk into the surface of the two adjacent stones; for doing which, a piece of thin plate iron was employed, with sand, upon the principle that stones are sawn; so that not only the sight, but feeling, could be employed in bringing them together again exactly; for the same or a similar plate being applied to the nick, the least irregularity of its position would be discoverable.—In a similar manner the stones of the Base Courses were marked by lines drawn parallel to the length of the steps, and others perpendicular to the same, the crossings being sawn in as before described. There was, however, a nicety in this part of the work that required particular attention, and that was in forming a provision for setting the four radical stones, that occupy the four radical dovetails into which each step was formed, as may be observed in the several figures of Plate No. 10.—Those stones were formed, from the work of the rock's being actually moulded off, as mentioned § 175: and from the manner already described of bringing those moulds to agree after they were brought home from the rock, § 176, those stones were laid upon the platform thereby, and then marked with lines upon their own substance, in the manner just mentioned: and as the distances of each of those stones were then ascertained by gauge-rods of white fir-wood, while upon the platform; it must be expected, as each step was reduced to a level plain, as the platform was, that when laid upon the rock in their due positions and distances, by the gauge-rods, they would nearly fit the dovetails that had been cut in the rock to receive them; and where there was the least want of fitness, as might possibly happen with bodies of so rigid a nature, either the stone or the rock was cut, till each stone would come into its exact relative position, and then all the rest would follow one another by their marks, in the same manner as they had done upon the platform.

236. IT is necessary to be noticed, that the waist of each piece of stone had two grooves cut, from the top to the bottom of the course, of an inch in depth, and three inches in width: applicable to those grooves, were prepared a number of oak wedges, somewhat less than three inches in breadth, than one inch thick at the head, nearly  $\frac{1}{2}$ ths thick at the point, and six inches long. The disposition of these grooves is shewn in the courses of Plate No. 10, where the little black parallelogram figures, placed along the lines describing the joints of the courses, represent the tops of the grooves, and their place on the right hand or left of the joint line, shew in which stone the groove is cut. It is also to be noted, that where the flank side of a stone was not more in length than a foot or fourteen inches, one groove was generally deemed sufficient; but those

of eighteen inches or upwards had generally, in themselves or the adjoining stone, a couple of grooves.

237. THE mortar, which was compounded as shewn in § 204\*, was prepared for use by being beat in a very strong wooden bucket made for the purpose; each mortar-beater had his own bucket, which he placed upon any level part of the work, and with a kind of rammer or wooden pestle†, first beat the lime alone, about a quarter of a peck at a time, to which, when formed into a complete, but rather thin paste with sea-water, he then gradually added the other ingredient, keeping it constantly in a degree of toughness by continuance of beating.—When a stone had been fitted and ready for setting, he whose mortar had been longest in beating came first, and the rest in order: the mason took the mortar out of the bucket; and if any was spared, he still kept on beating; if the whole was exhausted, he began upon a fresh Batch.—The stones were first tried, and heaved into and out of their recesses, by a light moveable triangle, which being furnished with a light double tackle‡, the greatest number of all the pieces could be purchased by the simple application of the hand; and this made our stones to be readily manageable by such machinery as could commodiously be moved and carried backward and forward in the yaws every tide. To the first stone, and some few others, we took the great tackle, that we might hoist and lower them with certainty and ease; but there were not in the whole above a dozen of stones that required it.

238. THE stone to be set being hung in the tackle, and its bed of mortar spread, was then lowered into its place, and beat down with a heavy wooden maul, and levelled with a spirit level||: and the stone being brought accurately to its marks, it was then considered as set in its place. The business now was to retain it exactly in that position, notwithstanding the utmost violence of the sea might come upon it before the mortar was hard enough to resist it.—The carpenter now dropped into each groove two of the wedges already described, one upon its Head, and the other with its point downward, so that the two wedges in each groove would then lie Heads and Points. With a bar of iron of about 2½ inches broad, ¾ of an inch thick, and 2½ feet long, the ends being square, he could easily (as with a rammer) drive down one wedge upon the other, very gently at first, so that the opposite pairs of wedges being equally tightened, they would equally resist each other, and the stone would therefore keep its place; and in this manner those wedges might be driven even more tight than there was occasion for; as the wood being dry, it would by swelling become tighter; and it was possible that by too much driving, and the swelling of the wedges, the stones might be broken: and further, that a moderate fastening might be effectual, a couple of wedges were also, in like manner, pitched at the top of each groove, the dormant wedge or that with the point upward, being held in the hand, while the drift wedge or that with its point downward, was driven with a hammer; the whole of what remained above the upper surface of the stone was then cut off with a saw or chissel; and generally, a couple of thin wedges were driven very moderately at the butt-end of the stone; whose tendency being to force it out of its dovetail, they would, by moderate driving, only tend to preserve the whole mass steady together; in opposition to the violent agitation that might arise from the sea.

239. AFTER a stone was thus fixed, we never in fact had an instance of its having been stirred by any action of the sea whatever; but considering the unmeasured violence thereof, the further security by trenails, suggested § 179, and now prepared, will not seem altogether unnecessary, when we reflect, that after a stone was thus fixed in its place by wedges, a great sea coming upon it, (often in less than half an hour) was capable of washing out all the mortar from the bed underneath it, notwithstanding every defence we could give it by plaster or otherwise; and that when the bed of mortar was destroyed, the sea acting edgewise upon the joint would

\* See also No. 1. of the Table in § 222.

† See description of tools and utensils, Plate No. 18.

‡ See also description, Plate No. 17.

|| Those were provided on purpose, being such as were used § 97, and saved much loss of time that would otherwise have attended the use of levels with Plumbets, which, (as far as I know) were the only ones then used in masonry.



exert the same power to lift it up, that the same sea would exert to overset it, in case its broad base was turned upright to oppose it; and as the wedges only fixed and secured the several pieces of which each course consisted to each other, and had no tendency to keep the whole course from lifting together, in case the whole should lose its mortar bed; it seemed therefore highly necessary to have some means of preventing the lifting the whole of a course together, till the solidity and continuity of the mortar should totally take away that tendency.—Adverting now to what was said § 179, that a couple of holes, to receive oak trenails of an inch and  $\frac{1}{2}$  in diameter, were bored in the work-yard through the external or projecting end of every piece of stone; we must now suppose these stones set in their places and fixed by wedges; then one of the tinnerns with a Jumper began to continue the hole into the stone of the course below, and bored it to about eight or nine inches deep; but this hole was bored of a less size, by  $\frac{1}{2}$  of an inch in diameter, than the hole through the stone above\*; in consequence the trenails having been previously dressed with a plane till they would drive somewhat freely through the upper hole, would drive stiffly into the under one, and generally would become so fast as to drive no further before their leading end got down to the bottom; and if so, they were sufficiently fast: but as they sometimes happened to drive more freely than at others, the following method was used to render them fast, for a certainty, when they got to the bottom.—The leading end of every trenail was split with a saw for about a couple of inches, and into this split was introduced a wedge about  $\frac{1}{2}$  of an inch less in breadth than the diameter of the trenail; it was a full quarter of an inch in thickness at the head, and sharpened to an edge: when therefore the head of the wedge touched the bottom of the hole, the trenail being forcibly driven thereupon, would enter upon it, till the whole substance was jammed so fast, that the trenail would drive no further; and as the wood would afterwards swell in the hole, and fill the little irregularities of boring by the jumper, it became so fast that, as it seems, they could sooner be pulled in two than the trenails be drawn out again†. The trenail (originally made somewhat too long) being then cut off even with the top of the stone, its upper end was wedged cross and cross.—There being generally two trenails to each piece of stone, no assignable power, less than what would by main stress pull these trenails in two, could lift one of these stones from their beds when so fixed, exclusive of their natural weight, as all agitation was prevented by the lateral wedges.—The stone being thus fixed, a proper quantity of the beat mortar was liquefied, as mentioned § 199, and the joints having been carefully pointed up to the upper surface, the Grout so prepared was run in with iron ladles, and was brought to such a consistency as to occupy every void space; and though a

\* The jumpers were kept to the same gauge by means of two brass rings turned to the proper size, so that when the jumpers by wearing became too little, they were sent to the smith to be made to their full size, by the hammer, according to the gauge ring referred to.

† It probably may be a satisfaction to the practical reader, as this mode of fixing by trenails may be useful on many occasions, to have some sort of proof of what is here advanced. He will remember the case of the stemming a hole for blasting rocks with gunpowder; that, after the proper quantity of powder is in, the ramming the hole, for five or six inches above the powder, with dry clay, or even the very powder of the stone that has been cleared out of the hole in boring, will, on firing the powder, produce so complete a resistance, that the rock will sooner be split in another direction than the stemming will be driven out of the mouth of the hole. Now this does not happen because the stemming is of more solid or tenacious matter than the rock itself, but because the power to drive it out can act only upon the end of it, equal to the area of the circle of the hole; whereas the hold by which the stemming (or wad) is retained in the hole takes place in every point of the surface of the cylinder that it occupies. As for instance, suppose the hole to be  $1\frac{1}{2}$  inch diameter, then the area of it is nearly one square inch; and suppose the length of the cylinder occupied by the wad to be 6 inches, then the circumference of a circle, whose area is one square inch, being  $3\frac{1}{2}$  inches nearly, the circumference of the whole cylinder so engaged will be 21 square inches; so that it would require a force 21 times greater than that whereby the matter of the Wad coheres to the solid, to dislodge it from the hole lengthwise.—I do not find an instance in my Journal, nor does my memory furnish me with one, wherein the necessity occurred of getting any trenail out again after it had been driven; had that happened, it must have been bored out again, as I know of no force that could have been applied, which would have drawn it out.

Having mentioned the affair of blasting, it perhaps may not be amiss here to add, that the efficacy of the gunpowder to split the stone, rather than to drive out the stemming or wad, is greatly owing to a further circumstance. The force of the powder to drive out the wad is only in proportion to the area of the hole; whereas its power to divide the stone in a direction parallel to the hole, is as the area of a parallelogram formed by the diameter of the hole, multiplied by the length that the charge occupies; that is, the diameter of a hole whose area is one square inch, being  $1\frac{1}{2}$  nearly, if the length is 6 inches, the product will be  $6\frac{1}{2}$ ; and so many times is the force that the same charge of powder exerts to split the stone, more than that to drive out the wad. Besides, every force exerted to drive the wad out of the hole, probably tends to make it take the stronger hold, in consequence of the parts of it being jammed harder together, as the force is greater.

considerable part of this was water, yet that being absorbed by the dry stones, and the more consistent parts settled to the bottom, the vacuity being at the top, this was repeatedly refilled till all remained solid: the top was then pointed, and, when necessary, defended by a coat of plaster.

The several courses represented in Plate No. 10, are shewn as they would appear, when completed with the whole of their wedges and trenails: and besides these, there being also generally two Lewis holes upon the upper surface of each stone, those served as temporary fixtures for the work of the succeeding course.

240. IT was the same evening's tide of the 11th of August, that the basement was completed and the center stone of Course VII. was landed.—Of the preceding courses, each was begun by the stones that engrafted in the dovetail recesses cut in the rock; these stones therefore being immoveable by any assignable force acting horizontally, rendered those so likewise that depended upon them; but having now brought the whole upon a level, we could not have this advantage any longer; it therefore became necessary to attain a similar advantage by artificial means.—For this purpose the upper surface of Course VI. (see Plate No. 10. Fig. 6.) had a hole of one foot square cut through the stone that occupied the center; and also eight depressions of one foot square, sunk into that course six inches deep, which were disposed at regular distances round the center, as is shewn in that figure: these cavities were for the reception of eight cubes of marble, in masonry called *Joggles*\*.—As a preparation for setting the center stone of Course VII. a parallelopiped (which for shortness sake I will call the *Plug*) of strong hard marble from the rocks near Plymouth, of one foot square and twenty-two inches in length, was set with mortar in the central cavity, and therein firmly fixed with thin wedges. Course VI. being thirteen inches in height, this marble plug, which reached through, would rise nine inches above it; upon this, the center stone (see Plate No. 11. Course VII.) having a hole through its center of a foot square, was introduced upon the prominence of the plug, and being bedded in mortar, was in like manner wedged (with wedges on each side the plug) and every remaining cavity filled with grout. By this means no force of the sea acting horizontally upon the center stone, less than what was capable of cutting the marble plug in two, was able to move it from its place: and to prevent the stone more effectually from being lifted, in case its bed of mortar happened to be destroyed, it was fixed down in the manner above described, by four trenails; which being placed near to the corners of the large square of that stone, they not only effectually prevented the stone from lifting, but aided the center plug in preventing the stone from moving angularly or twisting, which it might otherwise have done, notwithstanding its weight, which was two tons nearly †.

241. WHILE the center plug of this course was preparing to be fixed, an accident happened, which, without some present resolution, might have prevented my seeing the first stone placed. The level platform we then had obtained being something of a novelty, I was enjoying it by walking to and fro upon it; by some inattention I made a false step into one of the eight cavities for the *Joggles*, and not being able to recover myself, tumbled over the brink of the work down among the rocks on the west side; but the tide being then retreated, I presently recovered my former station, at first supposing myself but little hurt; but soon finding a very great and unusual numbness in one of my thumbs, on looking upon it, I perceived, from its irregular direction, it was put out of joint. I reflected that I was at least fourteen miles from a surgeon, and as far back again, and both ways subject to the uncertainty of winds and seas; I therefore laid fast hold of it with the other hand and gave it a violent pull, upon which it snapped into its place; and I immediately proceeded to fix the plug. I had not much pain or uneasiness from it the first tide; but it was above six months after this accident, before I could make free use of it.

\* When a smaller piece of stone, of any shape or kind, is let in between two larger stones, and partly into one, and partly into the other, so as to prevent their shifting place with respect to each other, those pieces of stone are termed *Joggles*.

† An Edystone silver medal (see Plate No. 18.) was laid under the center stone, together with several pieces of money.

242. AFTER setting the first center stone of Course VII. we immediately proceeded to set the four stones that surround it, and which were united thereto by four dovetails, projecting from the four sides of the center stone. These stones being fixed in their dovetails by a pair of wedges on each side, at bottom and top, as has already been mentioned, and held down by a couple of trenails to each surrounding stone, and still further steadied by joint wedges at the head of the dovetails, and also in the mitre or diagonal joints betwixt each surrounding piece; the whole formed a circular kind of stone of ten feet diameter and above seven tons weight: and which being held down by a center plug and twelve trenails, became in effect one single stone; whose circumference was sufficient to admit of eight dovetail recesses to be formed therein, so as to be capable of retaining in their places a circle of eight pieces of stone of about 12 cwt. each, in the same manner and upon the same principle, that the radial pieces of stone were engrafted into the dovetail recesses of the rock; and which being in like manner wedged and trenailed, we proceeded with circular Tiers of stone, in the manner shewn in Plate No. 11. Fig. 1.—It is however to be remarked, that the mode of applying the wedges and trenails being sufficiently explained in the several figures of Plate No. 10. and also in Plate No. 11. Fig. 1. to avoid a repetition of small work, the several succeeding figures simply shew the general shapes and disposition of the different pieces composing a course, and other incidental larger matters, wholly omitting the particular application of the wedges and trenails; yet it is to be observed that they were every where equally applied, till we got to the top of the Solid.

243. WE went forward with Course VII. without any thing but common interruption for some days.—It was remarked that upon the 12th of August, the wind being eastwardly, and moderate, there was the greatest swell in the Gut that we ever had experienced, when we attempted to land stones; the boat rose and fell full four feet perpendicular, which rendered the management of it, and landing of the pieces extremely difficult; and had not our purchases been very speedy in their action as well as forcible, we could not have done it at such a time; for after a stone was raised from the floor of the boat, the boat would rise under the stone so as sometimes to unhook it from the tackle, yet happily the boat sustained no damage: and having now seen the five stones of the center completely established, I left RICHARDSON and company, after setting the first of the third tier, to complete and go on with the rest in the same manner.

244. MY much esteemed master and friend Mr. WESTON, who came from London to be witness of our proceedings, arrived at Plymouth during this interval. I went off with him early on Wednesday morning the 17th, attended by Mr. JESSOP and his company, and landed upon the rock at ten; RICHARDSON and company were then about to begin to set the fifth tier, or circle of stones which was to contain the eight cubes before described.—These cubes were so disposed upon the surface of Course VI. that the cavities cut on the under side of Course VII. to take the upper half of each cube, should constantly fall in the broad part of the stones of the fifth circle; which will appear plain by considering the dotted lines relative to Course VII. upon the surface of Course VI. (see Plate No. 10. Fig. 6.) There could consequently be no application of wedges in the upper course to the fastening of the circle of stones (No. 5.) upon their respective cubes: when therefore the stones respectively came upon them, we put as much mortar upon the top of the cube, as would in part make good the joint betwixt it and its cavity, but not enough quite to fill it; because if too full there was no ready way for the superfluous mortar to escape; but a hole, of the size of those for the trenails, being previously bored through each of these pieces, answerable to the middle of each cube; when the stone was set, wedged and trenailed, then it was very practicable, by dressing a trenail so as to become a Ram-rod, to drive as much mortar down the hole as would completely fill every vacancy betwixt the stone and its cube; inasmuch that we soon perceived, that if this was attempted before the stone was completely trenailed down, that it would very easily raise the stone from its bed, as might indeed be expected from the principles of Hydrostatics: but being done after such completion, it brought the whole to the most solid bearing that could be wished; and when the cement was hardened answered the end quite as effectually as if they had been wedged.

It may here be very properly said, that since those cubes could be of little use in keeping the work firmly together before the mortar was hardened; and after that had taken place, they could



be of no use; because the number of 108 trenails, of which one of these courses consisted when complete, being supposed sufficient to keep it from lifting and moving out of its place; as the mortar hardened, and every additional course was an addition of its own weight upon the former, if those cubes could have been dispensed with in the first instance, they might have been so ever after.—This reasoning I can very well admit to be true; yet, when we have to do with, and to endeavour to controul, those powers of nature that are subject to no calculation, I trust it will be deemed prudent not to omit, in such a case, any thing that can without difficulty be applied, and that would be likely to add to the security.—It may further be remarked, that as this building was intended to be a mass of stone held together by the natural and artificial union of its parts, it would have been out of character, that when completed, it should be beholden to certain parts of Wood for its Consolidation\*.

245. I HAVE mentioned, § 83. that I originally conceived more than one way of preventing the courses from shifting place upon one another. My first conceptions were to form a rise (or a depression) of three inches, bounded by a circle somewhat about the diameter of that in which the joggles are placed; which step or depression would have formed a socket, whereby the courses would have been mutually engrafted, not much different from what nature has pointed out in the basaltine columns of the Giant's Causeway: but considering how much unnecessary trouble and intricacy would be hereby introduced, by one part of the bed of the same stone being liable to be three inches higher than the other, I judged that the end would be very sufficiently answered by the much more plain, easy, and simple method of joggles; especially as, for this purpose, the firmest and toughest kind of stone might be chosen, and the number multiplied at pleasure. One plug in the middle, of a foot square, and eight joggles of a foot cube each, of the hardest marble, disposed in the manner described, seemed to me, along with the additional strength and security arising from the trenails; as also from the infinite number of little indentures upon the surface of the courses, as well as the Lewis Holes, each being filled with an extuberance of mortar, which, when hard, would in effect become a steady pin; from the cohesion of the mortar as a solid, promising to be no less than that of the stone; together with the incumbent weight of every part of the building above; every joint thus separately considered, seemed in point of firmness so satisfactory to my mind, that if the whole of this proved too little, it was out of my power to conceive what would be enough.

246. WHILE I am upon this part of my subject, I will take an opportunity of observing that it was a part of my problem, which I will not take upon me to say that I have accurately solved; but I have endeavoured to do it, so far as my feelings, rather than calculations, would bear me out: That the building should be a column of equal strength, proportionate in every part to the stress it was likely to bear, (regard being also had to its use,) was a view of the subject I was naturally and forcibly led to, as I found it eternally rung in my ears from all quarters, that *a Building of Stone upon the Edystone would certainly be overset*. I therefore endeavoured to form it, and put it together so, that while a similarity of use permitted a similar construction, no man should be able to tell me at what joint it would overset; for, if at any given height the uppermost course was, when completed, safe, it became more safe by another course being laid upon it; and that upper course, though somewhat less in weight, and in the total cohesion of its parts, than the former; yet every course, from the first foundation, was less and less subject to the heavy stroke of the sea.

247. IN the morning and evening's tide of the 17th we set the whole of the fifth tier, and consequently the whole of the eight cubes were then inlaid. The morning of the 18th we again landed; but Mr. WESTON, after expressing his entire approbation of our proceedings, returned to Plymouth in the Assistant; I staid in hopes of seeing the whole course closed. In this morning and evening's tide, though rough, we had got set five pieces of Circle 6. and had landed the remaining three; as also one of the largest pieces of moorstone for the east side, (see Plate

\* Indeed the application of these cubic joggles so well accords with my feelings in respect to stability, that I should even now have regretted if they had been omitted; and should be sorry to have them now removed, if it was possible.

No. 11. Fig. 1.) This evening's tide we worked with links, and it began to blow so fresh that we had much ado to keep them in, being obliged to make a fire of them upon the surface of the work. We were under the necessity at last to quit the rock with some precipitation, and were very glad to get into our yawls; things being left in the following posture. Two of the pieces, Tier 6. were simply dropped into their places on the north-west side, while the third piece, being about a ton, and the piece of moorstone near upon two tons, were chained together, and to the work of Course VII. that was already set; these two loose pieces being upon the top of that course near the east side: the triangles were lashed down upon the floor of the work, as we had practised several times before.—The sea became so rough in the night, that the *Weston* at the transport buoy was obliged to slip and make for an harbour. Next day the wind increased, so that the sea broke over the shear-heads at low water. I waited in hopes of an alteration of weather till the 22d, when I returned to Plymouth in the yawl, the wind being S. W.—Upon the 25th, though the weather continued still bad, the Assistant carried out *RICHARDSON* and company, and brought home Mr. *Jessor* and company, who left every thing well upon the rock, as far as they could discover from the buss, but had shared their last pound of bread. The bad weather still continued to increase till the 28th, when there was a violent storm at S. W. so that the *Antelope* man of war in the Sound, of fifty guns, dragged her anchors, and was in great danger of driving upon the rocks.

The 29th I perceived with my telescope, from the *Hoa*, the buss to ride safe, but could not see the shears, or indeed any thing else upon the rock distinctly, except the breakers. The day following being more clear, and the sea somewhat subsided, I distinctly saw the buss and the rock; but the shears not being visible, I immediately went on board the *Edystone* boat to reconnoitre the state of things, and left orders with Mr. *Jessor* in the mean time to prepare new shears.—The wind being N. W. I passed the rock several times under sail, but there was no possibility of landing.—I observed that not only all the work which had been completely set was entire, but that the two stones mentioned to have been simply lowered into their places also remained therein, and that the 5 cwt. still rested upon the stone whereon it was left. The west face of the building had got so complete a coat of sea weed that it was only distinguishable from the rock by its form: but the shears and triangles were entirely gone; the two pieces of stone that had been chained together and to the work, were also gone; the windlass frame broken and much damaged, and the roll gone; the fender piles and the transport buoy however remained in their places.—The buss I was told had rode it out very well, but not without frequently alarming the company on board, with an apprehension of her breaking loose, she having shipped many heavy seas on deck, and one so great they expected the deck to have been staved in; they had veered out seven fathoms of bridle cable, but were afraid to ease out more, lest it should touch the rocks.—This was in reality the greatest storm we had ever experienced while out at the rock; yet we were less chagrined for the damages done, than thankful that they were not greater.

248. THE 1st of September *JESSOR* and company went out to shift *RICHARDSON*; who sent me a letter, informing me they had caught an opportunity of reconnoitring the Gut, and found the two stones washed off from the rock to be lying therein, and which, as he apprehended they could be weighed, there would be no need to proceed with new pieces on shore. It was the 3d of September before this company could make a landing to do any thing upon the rock; so that since the 18th ult. there had been an interval of fifteen days in which we had been totally interrupted by bad weather in the very prime part of the season. However, every thing having been expedited on shore to get refitted for work, this day I went out therewith, and began to set up our new shears, windlass, &c. and with the shears got up the piece of Portland of Circle 6. which was set, as also the others that had been left loose in their dovetails; but the tide of flood coming on, had deepened the water too much before we could try to get up the other.

The getting up of the piece of Portland stone was effected by means of the same utensil wherewith we got up that mentioned § 228; and though it lay the wrong side upward, yet as the trenail holes always reached through the stone, into which the instrument was introduced, (see its description,) this difference of circumstance was at present of no consequence; but when the next day we introduced it into one of the trenail holes of the piece of moorstone, that lying

also the wrong side upwards, (for the holes being bored from the upper side, were therefore naturally a little taper), this circumstance prevented the pin from going in so far as it otherwise would have done; the holes being also nearer the corner, and the stone double the weight of the former, when the stone was got up to the surface of the water, it then becoming heavier by losing its buoyancy, the pin became bent, and thereby the hold of the tool upon the stone releasing, it dropped down again to the bottom; it however fortunately fell upon its end, and in this position we found means to get a chain round its waist.—To one of the strong chains, which were about ten feet long, wherewith we used to chain our loose pieces of stone upon the work when we left them, we fastened a rope to each end, and lowering the chain in a loop beyond it, we could then, by bringing the two ropes together, bring the chain round the waist of the stone; but the difficulty was to confine the two parts together so close to the stone, as to prevent its turning out of the chain when we came to heave upon it: for this purpose I bethought me of putting an iron ring over the double rope, the weight of which might draw the two parts together; but that not proving to do it sufficiently, while expedients were concerting, JOHN BOWDEN, whose invention was ever ready, cried out, "Twist the ropes, master;" and by this simple expedient, the parts being drawn so close that the ring went home, it was impossible for the stone to slip, and therefore, not long before it was relanded upon the rock\*.—The depth of the water was twelve feet.—The three parts of the Lewis by which this stone had been chained, were found in the hole, but the bolt and shackle were gone. The like parts of the lewis were left in the work to which the same chain was hooked, but the bolt was gone, and half of the shackle found in one of the cube holes. We also remarked that the surface of the work upon which the stones had lain, that had been chained, was brought almost to a polish, as well as the under bed of the Portland piece that was driven into the Gut.—As the shears were fastened at the top as well as the bottom, it is difficult to suppose they could at once leave the rock; most probably therefore it was the legs of the shears that broke the windlass after one or both had got loose at bottom; otherwise it is not easy to imagine that the water could lay such hold of its frame as to break it in the manner it was broken, being wholly of iron. (See Plate No. 14. Fig. 1.)

249. SEPTEMBER the 5th the seventh circle was finished and the eighth begun; and this day the wind being variable from N. E. to N. W. and very moderate, was remarkable, as being the first time of the people having worked, till they were obliged to quit the rock for refreshment: and now every thing being reinstated, it was some time before we met with any but the ordinary interruptions.—On the 7th I had notice from Mr. JESSOP of his expecting to complete Course VII. that day, being the first circular course: I therefore went, accompanied by Messrs. WESTON and RICHARDSON, on board the Edystone boat, which was loaded with the center, and its surrounding stones, of Course VIII. We arrived at the buss in the night, and were informed by Mr. JESSOP, that the weather had been so calm that the top of the work had not been wet for three days; that therefore they had worked from light in the morning to dark in the evening, but not in the nights. That Course VII. was completely closed, pointed and grouted; and that the top of the work, where it needed, had been levelled, and every irregularity in the face of the work rectified.—In the morning of September the 8th, we landed at break of day, and the Edystone boat having been unloaded, we proceeded to set her cargo: and, besides the satisfaction that Mr. WESTON enjoyed in setting the center plug of Course VIII. which was managed in all respects as already described of Course VII.† he was entertained with the appearance of a fleet around us, consisting of a convoy of above a hundred sail of West India and Mediterranean

\* On this occasion it may not be amiss to observe the great advantage that arises, in the greater operations of mechanics, from the having commodious tackles and utensils. We had not completed the setting up of the windlass, when we found it necessary to heave up the two stones before mentioned; we therefore (applying a sufficient number of men to the main tackle) heaved them up by hand: and though there was no difficulty in this, yet I could not help remarking the vast difference there was in the Time and Power, between the application of men's strength in this way and by the windlass. I therefore afterwards purposely noted the minutes they were in heaving up one of the large moorstone pieces of Circle 7. by hand from the boat; and by the time this was done the windlass was completed; and then, by a similar trial therewith, found that four men at the windlass hoisted a stone in half the time that it took twelve men to do in heaving by hand, though the Tackle remained the same to both.

† It may be necessary to say, that this center plug was four inches shorter than the first; because Course VI. being thirteen inches thick, was four inches more than half the medium thickness, of the courses above, which were eighteen inches at an average.



merchant ships; to whose future safety, we had the satisfaction to suppose ourselves contributing.—After setting the plug and the center stone, Mr. WESTON returned to Plymouth.

The fineness of the season now continued to favour the expediting of our works, insomuch that Course VIII. which was begun upon the 8th, was executed in five days, being entirely completed on the 13th at the same hour. Every thing went regularly on till the 20th; so that in return for our continued interruption from the stormy weather for fifteen days, our works had an uninterrupted progression for eighteen days, when Course IX. was advanced to the fifth circle: but at this time, notwithstanding the wind had been moderate at E. for a week past, yet there came on so great a ground swell from the south-west, that though both the companies had used their joint endeavours to get the Edystone boat into the Gut, they had not been able to effect it.

250. THE greatest hinderance we had met with during the last fine season arose from the uncommon lowness of the tides, which were so much so, that our stone vessels were liable to be caught by the keel in going out from the Jetty head in Mill Bay. This inconvenience was in a great measure remedied by a thought of Mr. JESSOP's, who contrived to borrow a Punt or flat square vessel, which, being loaded at the Jetty Head, was then hauled out into deep water, where her cargo could be shifted into the boats of passage, at any time of the tide.—An incident however happened, respecting our use of this punt, that demonstrates the extreme degree of malevolence which sometimes possesses the breast of man. She was loaded on Monday the 12th in the evening, and hauled out as usual; and the next morning (the night having proved uncommonly calm) the punt was found, on hauling up her moorings, to be swinging by a single yarn, the rest having been cut with a knife, at three fathoms under water; doubtless that it might not be discovered, otherwise than by the effect of the vessel's being driven upon the rocks, and there sunk with her cargo, to our no small disappointment in the progress of the work: a circumstance, that as it could not contribute to any man's advantage or pleasure, indicated a degree of turpitude, at which, were it not for such instances as these, it could hardly be supposed the human mind was capable of arriving.

251. IT was not till the 25th that any of the boats could keep the sea; for when they attempted to go out, they were as often obliged to return with their cargoes: however, the Weston's cargo being first wanted; J. BOWDEN, always desirous to promote the service to the utmost of his power, went out this day to the transport buoy, with a resolution to ride it out there if possible, and which, with great difficulty and some hazard, he did; and in the evening of the 26th his cargo was landed, which enabled the work to go on again as intervals offered. I went out on the 27th, and was witness to the great difficulty there was in preserving the boats from being wrecked in the Gut; the easterly wind having raised so great a swell on that side of the rocks, that two of them successively broke their fastenings, and were in the utmost peril of being staved; yet steadily endeavouring to use our best efforts to expedite the work, no material damage in reality happened; though the boats rolled to that degree, that every moment one would have expected the mast of the vessel and the shears to have got entangled together so as to carry one or both away.

252. THE 29th of September all the remaining pieces belonging to Course IX. were happily landed from the Weston, and the vessel got clear of the Gut.—We found the best method of a boat's going into the Gut was; when she arrived at the transport buoy, for one of the yawls to carry her a rope to the landing-place, as also one to the principal rocks on each side, entering the Gut; those on board then heaving upon whichever of these three seemed most requisite, also veering out a sufficient rope double from her bows, and passing through the ring of the transport buoy, she goes into the Gut stern foremost; and by these means has a fastening head and stern, as also one on each side.—When going out of the Gut, she heaves by the double rope towards the transport buoy, and when clear of the rocks she can either go to the buoy, or, by the rope's being double, she can slip her hold of it, and get under sail.—A ground swell coming from S. W. soon after, obliged us to quit the rock; but the next day we landed, and set the remaining stones, which completed Course IX; and the masons proceeded to rectify the face of the work, where it was

in any degree wanting thereof, that there might be no need hereafter to disturb any part of the coat of weed, which was likely to fix upon it during the winter.

253. BEING now arrived at the eve of October, I maturely considered our situation; and finding that we had been eighteen days in completing the last course, whereas the former one (Course VIII.) was begun and finished in five; though the weather, both on shore and above-head, had remained to all appearance much the same; I from thence concluded it to be very probable, we might not get another course completed in the compass of the month of October; so that when I reflected on the many disasters we had suffered last year, by continuing out till the month of November, and how little work we in reality did after this time, it appeared to me very problematical whether we might be able, with every possible exertion, to get another course finished this Season: and considering how very ineligible it was to have a course lie open during the winter, in this stage of the work; and that we had now got three complete courses established above the top of the rock, the sum of whose heights was four feet six inches; and that we could not leave the work in a more defensible state, whether as relative to the natural violence of the sea, or the possibility of external injuries; from these considerations, it appeared to me highly proper to put a period to the out-work of the present season; and this opinion was heartily concurred in by Messrs. JESSOP and RICHARDSON.

We therefore proceeded to take down the shears and windlass, and to weigh the transport buoy chain and anchor, which we successfully did, by applying all hands thereto on board the Weston; but in effecting this we providentially escaped what, if it had taken place, would have proved in all probability a very unfortunate disaster.—The anchor, as mentioned § 224. being of 12 cwt. was a heavy one in proportion to the size of our Craft; and it was weighed by means of its buoy rope, and got close to the bows of the Weston. The chain of the transport buoy then hung down in a loop from the ring of the anchor, the other end being supported by that buoy; which, that the whole might float together, was confined to the side of the Weston by a small luff-tackle which laid hold of it.—We then proceeded to hoist the transport buoy into the Weston by her runner and tackle, from the mast-head; but the hook being too small to encompass the ring of the buoy; it was fixed by means of a salvageee; and this small circumstance saved us; for by the time the buoy was hoisted out of the water, observing that its weight and appendant chain a good deal heeled the Weston, and was in consequence making a strong effort to quit the vessel's side, I ordered the tinnors to hold fast the luff-tackle, which they unfortunately mistook for an order to let go the luff-tackle; on this the buoy immediately quitted the vessel's side: I happened to be with others in the yawl on the outside of the buoy, where we had been fastening the salvageee; and seeing the buoy separating from the vessel, and driving us outward, and that the weight of the buoy and chain was gaining more and more purchase upon the mast, as it heeled more outward; in consequence, there being nothing to prevent the further separation of the vessel and the buoy, this advantage must have become every moment greater, till the vessel had overset, filled, and sunk: in this dilemma it occurred to me to make use of my Pocket Knife to cut the salvageee; which being instantly done, the Weston immediately righted, and the buoy was soon after got on board in the manner it was first intended.

254. THE 1st of October we proceeded to heave in the bridle cable of the buss, and instead of it to fix to the great swivel of the moorings (which we found unhurt) a new buoy chain that we had received from London, to be applied instead of the other; which being made with short links, would relieve us in future from the anxiety we had in heaving up the bridle chain and swivel the beginning of this season. (See § 223.) This was put down, and the great buoy and chain affixed upon the top of it, which had rode the whole of last winter, and had served us as a transport buoy during the season we were then about concluding. The buss was now rode by this buoy till the wind should come fair to carry her into harbour; the whole being ready to cast off at a moment's warning.—This business being completed, and a good opportunity of landing on the rock offering itself, I again went upon it with Mr. Jessor and the masons; and having completely rectified the outside, and finished every thing to my mind, we went on board the

Weston and Assistant with the company, leaving the buss to the care of the seamen, who were all on board, except the two masters of the boats, BOWDEN and MEDLING, in their respective vessels, and landed at Plymouth the same evening.—The next day, Sunday October the 2d, BOWDEN and MEDLING went out to assist SMART and the other seamen in bringing in the buss as soon as the wind came fair.—They sailed with the buss on Monday the 3d at four P. M. but it was not till the next day at noon that she arrived at Mill Bay: she was hauled up upon the beach the same evening, and I took leave of the work-yard for that season; exhorting the men to diligence and unanimity, and leaving every thing about the work up to the entry door ready to go to sea, which was intended to be pitched upon the fourteenth course, I set forward from Plymouth for London the 5th of October\*.

\* Besides what precedes, in relation of the incidents of the last season, I have omitted one in its proper place, that may indeed be esteemed more of a ludicrous than a serious nature; and, as it was not set down in my Journal at the time, depends now altogether upon my memory; as however the thought might, in like case, have its utility, I will give it a place in this note.—I think it was after we had got the shears refitted, after the storm § 248. I was desirous to shew the people the advantage that might be had from the construction of the shears, in enabling us to get off from the rock, in case any of us should be left there, when the yawls could not possibly go alongside to take us off in the usual way: and, to introduce the affair the more readily, I set about to give them an example. From Plate No. 14. it will appear that the shears were kept upright, and were managed, by two strong guy (or guide) ropes, one passing from the head of the shears over the area of the house, which was fastened to the rocks, above low water, on the west side of the rock; the other, counteracting it, passed over the Gut, and was fixed to one of the rocks in the south reef on the east side of the Gut. This last rope therefore wholly crossed the Gut, obliquely from the top of the shears, down nearly to low water mark. I mounted to the head of the shears, and clung upon the guy rope, and, as the descent was with a considerable declivity, it was easy to work myself downwards, which I did without difficulty, till I approached somewhat near the surface of the water; I then ordered the yawl to come underneath me, to take me in, and when I found my feet in the boat, I concluded I had nothing to do but quit hold with my hands; but the very moment in which I quitted hold, the boat took a sudden yaw or sheer, which canted me overboard, headlong into the sea. No ill consequence however happened, except a thorough wetting to myself; but failing of ultimate success, though by means of a collateral circumstance not necessarily connected with the operation, no one ever repeated the trial; that is to say, we were never put to the real want of it; though every one present was convinced of the practicability of the manœuvre, in case necessity should in future call for it.

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## CHAP. II.

### COMPREHENDING THE ACCOUNT OF TRANSACTIONS FROM MY LEAVING PLYMOUTH IN OCTOBER, 1757, TO THE CONCLUSION OF THE WORKING SEASON OF 1758.

255. **T**HE interval between the conclusion of the outwork of the year 1757, and the commencement of that in 1758, furnished some memorable events.—The first that happened was of an untoward nature. In the beginning of December there happened a violent storm, so great as to drive the floating light from her moorings, and oblige her to go into Plymouth; and from whose master we learnt, that in passing by the Edystone all then appeared to be well. From this time the weather continued so tempestuous that it was the month of March before any of our boats could venture out to reconnoitre, when I received a letter from Mr. JASSOP, containing the disagreeable news, that the great buoy of the moorings was gone, as also the buoys of the anchors; but that the seamen were at work sweeping for the anchors, and though they had not been so lucky as to find them, yet when the weather became more favourable, they did not doubt of success.—This was a matter that required the fullest attention; and, on a consultation with the proprietors, it was determined not to rest the matter solely upon the efforts of our seamen, but, to spur the whole body of fishermen, &c. upon the coast to exertion, a reward of £.50 was offered to whoever should recover the moorings. At the same time it was further determined not entirely to trust to our hopes of finding them, and therefore, without loss of time, a new set of chains was bespoke of Mr. WILSON of Blackwall, who had made those already described; so that these might be going on while endeavours were used to find the former; and if found, there would be no other loss, than



that we should have so much spare chain upon hand as should be made at the time; and which, as what had happened might happen again, there possibly would be occasion for in future. This matter being therefore now in a proper train, I shall proceed to an event of a more pleasing kind.

256. THE proprietors of the Edystone acquainted the Corporation of TRINITY HOUSE that their engineer being now in town, and, having made a considerable progress with the work upon the rock, was, together with themselves, desirous of giving them full information of the proceedings; and that nothing would be more satisfactory to the public, as well as to themselves, than to merit their approbation. This was the 21st of March, and on the 22d they received an answer from Mr. SHUTTLEWOOD, Secretary to the Corporation, appointing the Saturday se'nnight following.

In this interview I had the pleasing satisfaction of fully explaining to that honourable Board, not only what I had done, by means of the models and drawings I had laid before the Board of Admiralty, but also what I proposed further to do; observing, that what was already executed would equally serve as a very firm foundation and basement for a Timber structure, in case it should be their opinion that such a one would be preferable to that of stone proposed: but after a full investigation, they were pleased to honour the proposition with their decided opinion, that nothing could answer so well as the building proposed; which opinion was still the more acceptable, as it was that of the most competent judges.

The Board, after many enquiries concerning the place and manner of our moorings, were pleased to offer me a set of mooring chains, they had at Falmouth, in case we should need them, which though neither new nor so heavy as those prepared, by their directions, for the Neptune buss, yet might serve on occasion, as we did not expect to continue out in the worst of the season. The corporation were also pleased to desire me to give them at times an account of my proceedings and progress, from Plymouth; by their doing which, I esteemed myself much honoured, as well as obliged by the offer of the chains.

257. AFTER this the accounts from Plymouth continuing constantly the same; that every thing was going on briskly in the yard; that the season was but little favourable to the sweeping for the recovery of the moorings; and that the attempts which had already been made, proved abortive; I took a resolution of going down to Plymouth, though not by way of proceeding with the building, till the season arrived when the weather was more likely to continue settled, as well as fine; yet, as I had frequently found difficulties to be surmounted when I was present, that continued obstacles when I was absent; and though the operation of sweeping\* was not a thing to which I had been accustomed, I notwithstanding found myself much inclined to be present, in order to expedite the business as far as in my power.

258. I ARRIVED at Plymouth on Sunday the 16th of April, and found every thing at Mill Bay to my satisfaction; the last cargo of stone from Portland having been delivered in December, and Course XXXI. was in hand working, being that whereon the windows of the second room were to be placed. The solid part of the house was entirely completed and off the platform, so that had our moorings been in readiness, I might have been tempted to have carried out the buss. —But I was scarcely arrived at Plymouth before an express came after me, upon a difficulty that had arisen in the progress of the Calder Navigation Bill, and I was wanted to attend a committee of the House of Commons, upon the 24th instant: I therefore was obliged to content myself with a consultation with our seamen and Mr. JESSOP; and it was their opinion, that as, from the roughness

\* The operation of sweeping for an anchor is as follows. A couple of boats of a proper size are manned; and, as near as they can judge of the place where the anchor lies, they, at a competent distance from each other, row or sail abreast, having a hawser or small cable passing from one boat to the other, and of such a length that a considerable part of it may drag upon the ground. This, on a plain bottom, will naturally hang upon the arm of the anchor standing obliquely upward; provided the shank of the anchor lies eastward, that the tide runs west at the time of taking the sweep, and the boats are moving with the tide; for it is evident, if the hawser hooks upon the anchor, that the two boats will tend to come together; and, the two parts being brought into one boat, if she heaves upon them till she approaches nearly over the anchor, as the cable will be prevented by the broad part or Fluke from slipping off the arm, a proper purchase being then applied, the anchor may be weighed.

of the rocks at the bottom, the anchors would naturally get into the hollow places, the sweep ropes had constantly gone over without touching them; and therefore they advised to sweep with a small rope, not sufficient to weigh the anchor; but first to hook it, and then to sweep with a larger rope with weights upon it, so as to sink it into the hollows, and thereby catch the anchor also.

259. IN this situation I left our seamen to make the trial, the promised reward not having as yet excited any others to the attempt. I attended upon the 24th at the House of Commons, and upon the 30th was back again at Plymouth; when, on my arrival I was told by the seamen, that by the scheme concerted before I left them, they had the preceding day the good fortune to hook one of the anchors, which they weighed off the ground; but were unable to bring it to the surface, on account of the heaviness of the chain to which it was fixed, and the smallness of our vessels; however, they had secured the sweep rope by letting drop a Runner-Ring, as mentioned § 248, and had fixed a buoy thereon.—It happened that the tides ran so remarkably short at this time, that our buss did not float at high water. We therefore procured the use of a sloop that lay in the harbour, which the very next day was fitted out with a roll proper for heaving up the anchor and chains; and, at three in the morning the 2d of May, I went on board with Mr. JESSOP, all our seamen, and eight or nine hands from our yard; the Assistant accompanying us. We arrived at the moorings at eight; at first we could not see any thing of the buoy the seamen had fixed, but when the tide was fallen away we got sight of it, and soon weighed the mooring anchor; but by the time we had got it above water the wind began to freshen at east, and raised such a swell that we durst not attempt to get it upon deck, so as to haul in the chain and come at the bridle; and therefore were obliged to be contented with securing our temporary buoy rope upon the anchor, lowering it down again to the bottom, and then return to Plymouth.

The weather remained unfavourable till the 11th of May, when we went out with the buss; and, having considered the numberless disappointments which we had experienced, chiefly as it should seem, from the stiffness of the ropes and unevenness of the bottom, I had determined to get a six inch cable laid of a sufficient length for such purposes, and the yarns to be so loosely twisted together that it might be considered as of the nature of a Salvagee: carrying this along with us, and finding the place of the anchor by means of the buoy we had fixed upon it, we laid effectual hold of the anchor with it, which was in twenty fathoms water, and soon got it up to the bows; but when we began to heave in our ground chain, we found it to come in much heavier than we expected. We thereupon fixed our great tackle to it in addition, and hove all taught, but without procuring any more of the chain. We therefore made all fast, and, it being nine P. M. concluded to let all stand till the next morning. The wind then beginning to freshen at E. the buss got some motion, and while we were refreshing ourselves there came on a sudden rumbling of the chains, which put the buss into so great a tremor, that we concluded the chains were gone overboard to the bottom; we ran upon deck, and, to our great surprize, found all standing as we left it: after this two or three more rumblings ensued, but gradually less; so that it would seem the chains had by degrees disentangled themselves from the rocks, as after this the buss rode without any particular strain upon the tackle; and the wind continuing fresh, we did not resume our work till day-break on the 12th.—The ground chain now came in kindly, and about ten o'clock we came to and got in the bridle and swivel, the buoy chain being fast thereto; as also the under buoy and the upper chain; which, as it appeared to me, had sunk the under buoy to the bottom, it being much water soaked. In fact, we recovered the whole of our moorings, except the upper or great buoy, and the bolt by which it had been fixed; so that from the appearance we concluded the failure had been in the Forelock\* of the bolt; but whether it had gradually worked itself loose by the continual motion, or by some violent jerk of the sea, or blow from some vessel's having run upon it, we could not determine.—By three o'clock we got the chains and the anchor lowered, and the buss as completely moored, in our own opinion, as she ever had been in either of the former seasons; which, considering the number of disappointments we had experienced, must be supposed to have been attended with unusual joy and satisfaction.

\* A Forelock, in shipwrights terms, is the key or wedge by which a bolt is drawn tight, or prevented from slipping out.

260. DURING the time I was out upon this business, I took an opportunity at pinch of low water to view the works upon the rock. It was with no small difficulty that I landed; but I was much surprized, notwithstanding what had been reported of the soundness of the work, to find it so perfectly entire; for, except a small spawl which had been washed from the rock itself, the whole did not seem to have suffered a diminution of so much as a grain of sand since I left it on the 1st of October: on the contrary, the cement, and even the grouted part, appeared to be as hard as the Portland stone itself; the whole having become one solid mass; and indeed it had that appearance, as it was then entirely covered with the same coat of sea-weed as the rock, the top of the work excepted, which was washed so clean and white, that the lines thereon appeared more distinct than they had done upon the platform in the work-yard; no weed having fixed upon the upper surface except in the cube-holes and lewis-holes, which constantly holding water, were grown over with green weed like the outside. The fender piles were indeed all gone, but this was a trifling disaster, as they could soon be renewed; and we thought ourselves happy in the prospect of getting to work upon the rock so early in the season.

261. SATURDAY the 14th of May the whole of the Portland stone work being completed in the work-yard, the stone-cutters in that branch were dismissed: and upon the 16th the fender piles at the rock were restored; contenting ourselves now with two, fixed as is shewn in Plate No. 14. The shears, the windlass, and all the rock tackle, with the transport buoy, being completely fixed\*, our boats were now loaded with stone, and the first sailed to the transport buoy; but though the weather was not favourable for delivering their cargoes, yet it being seasonable, I determined they should keep out from Mill Bay, that they might take the earliest opportunity, and no time be lost. And now, what could hinder our progress? Yet such however is the uncertainty of human affairs, and particularly of those that depend upon the state of the winds and waves, that, from this time till the 2d of July, instead of prosecuting the work, our thoughts and attention were wholly employed to remedy disasters.

262. HAVING employed the 16th of May in writing an account of our late proceedings to the TRINITY BOARD, I went out to the buss to take the first opportunity of landing the center stone of Course X. the vessel that had it on board riding at the transport buoy; thus every thing continued fair and promising, and we expected every hour that the ground swell would subside sufficiently to give us leave to get the vessel into the Gut. In this state we were obliged to wait from day to day till the 23d, when, about three o'clock in the morning, the watch upon deck came down to acquaint me that the buss had dragged her eastern anchor, for that she had got a considerable distance from the buoy; whereupon we all hastened upon deck, and found that we had really got out of the accustomed place; however in a little time the buss came apparently into her former situation, and finding the bridle taught, we concluded she had taken some extraordinary swing, and that all was come right again. After waiting awhile for the approach of day, we could not discern our buoy, and we observed that we were removed further from the rock, so that, on applying to the bridle a second time, we found that the chain was dragging upon the rocks: but how it had been separated, as the buss had not rode with any extraordinary strain since she was last placed at her moorings, we could by no means guess; and finding that we still continued driving from the rock, we concluded to drop an anchor as soon as we got into clean ground. The spring-tide of flood however came on so strong, that though the wind blew a fresh gale at E. we were carried so fast to the eastward that we concluded it unsafe to anchor, and therefore advisable, for the present, to bend our sails (which had indeed been all unbent and stowed down in the hold for the summer) and try to gain Plymouth Sound; which being done with as much dexterity and readiness as could be expected from three seamen, assisted by masons and tinnors, we got under way, and proceeded to heave in our bridle cable, at the end of which was the great swivel with the five fathoms of chain that had been added at the end of the last sea-

\* During this interval upon the rock the masons were employed in reducing the whole area of the work to a strict level; and it was very agreeable to observe, that the strokes of the mallet and tool were equally complete and perfect in driving a fair chisel draft across the joints, as upon the entire stone; which was a proof of the firm coherence of the component matter.



son, but nothing farther; and finding that even the swivel had struck against the rocks, we concluded that the bolt and shackle, joining this chain to the former, by some accidental stroke had got its forelock broken or beat out\*, and then, by the continual working of the sea, it could not be long before the shackle became unbolted, and in consequence the vessel set adrift: but having carefully placed a buoy upon our western anchor, we were not apprehensive of any other ill consequence from this accident than the hindrance which the repetition of the same operation that was performed upon the 11th and 12th instant must necessarily occasion.—At ten o'clock on the 23d we came to an anchor in the Sound; from whence the winds and seas prevented our stirring for several days.

263. THE 3d of June, at two A. M. I went with Mr. JESSOP and company on board the buss, and got out near the rocks at nine; but how great was our surprise and mortification to find that the buoy, which we had taken great precaution to secure upon the anchor, was gone. We therefore came to an anchor about a mile to the N. W. of the rock, which we judged to be in clean ground, and I went in a yawl with Mr. JESSOP to make enquiries at the floating light. —The master informed us, that on Wednesday the 24th ult. he went on shore in his boat; but it being then thick weather, it was thought advisable to make the rock in their way to Plymouth, that they might more readily hit the Sound; and he then observed the buoy floating, and that two Polparra fishing boats were in sight.

On our return to our station about twelve we began to sweep for our moorings as before, but without success; this we repeated at six, when the tide became again favourable; next morning we tried again, and laid hold of something which we judged to be the under buoy of the western anchor; but the tide running too strongly, prevented us from using our salvagee rope: we therefore went upon the rock, where we fixed the chains and rings for steadying the boats in the Gut; and after clearing away the weeds from the cube holes, we set the center plug ready for fixing the center stone of Course X; which done, we returned to our sweeping work, not doubting but that we should be able to hook the under buoy with the salvagee rope, and we accordingly constantly met with it; but the weather being untoward, the short sea raised thereby occasioned so great a motion of the yawls, as to cause the sweep rope to disengage itself from its hold: and soon after there came on so great a sea as to prevent all further trial at present, and made it prudent for us to weigh the buss's anchor; so that in the evening we arrived with her in Mill Bay, through a rough sea, fresh wind, thick fog, and rain.

264. WHAT we had been told by the master of the floating light could not fail to give us some suspicion of the Polparra Fishermen, as having cut away the buoy for the sake of the cork; a jealousy I should not have given way to, if I had not recollected the cutting the moorings of the punt the last year, and several other instances of villany of like nature, which in such cases it would be always worth while to endeavour to detect and punish. With this view I accepted the offer of a friend in the Custom House, that I could depend upon, to go to Polparra; and, under colour of searching for run liquors, to try to discover the buoy; which was accordingly done, though without further success than a confirmation of our suspicions: for they learnt that three boats had been out the very day the master of the floating light saw the buoy in his way to Plymouth, and that they had brought home a large parcel of fish of a kind peculiar to these rocks; so that they might easily have disengaged the layers of cork composing the buoy, and cut them to pieces for their Crab-pots and Seines, while at sea, to prevent discovery.

265. FROM this time we were always prepared to go out in search of our moorings, and frequently attempted it, but were obliged as often to return. On Friday the 23d, the Weston and Assistant having unloaded their cargoes of stone, our men went out with a declaration that they would not return till they had found the moorings. They did not come back in some days; and, as I was not able to see any of the boats with my telescope from the Hoa, the Cawsand

\* As this bolt and shackle would necessarily be in review on getting in the bridle, as mentioned § 259. the cause of this derangement must have happened after that.

fishermen also reporting that they had not seen them at sea, and it had blown very fresh all the time, we began to be uneasy for them; imagining they had shared the same fate as a fishing boat, which about three weeks before had been picked up by the French for the sake of intelligence: but upon the 28th of June in the evening they returned to Plymouth, having, by distress of weather during the interval they were out, been obliged to take refuge in Yealm harbour, where they lay two days and nights, and afterwards returned to sweep for the moorings; in which trials they still laid hold of something with their sweep rope, but never had the good luck to lay hold of it with the salvagee rope; however they continued their trials till wind and weather drove them in.

266. DURING this time we received a parcel of chain from the smith in London; for, as he had continued very diligently at work upon the new chains, that were ordered upon the first discovery of the loss of our buoy, and had proceeded with them till we had got (as we thought) completely moored upon the 13th of May; the quantity of chain then made, amounting to forty fathoms, was, by way of precaution, immediately put on board a vessel that was about to sail for Plymouth, and was now fortunately in our possession. We had moreover received the Corporation's chain from Falmouth, amounting to twenty-seven fathoms, and had ready two mooring anchors, which had been purchased when the new chain was bespoke.—In this state of things, as the season was approaching that we might expect suitable opportunities upon the rock, and loss of time being the greatest loss that could happen to us; on a consultation, we judged it proper to spend no more now, in sweeping for the moorings, but to carry out the buss and moor her in the best manner we could with the chains we had; because this would not prevent a proper endeavour to recover the moorings, when time and season was less precious: and though the Corporation's chain of twenty-seven fathoms was not above half the weight of an equal length of our own, yet we judged it might be very sufficient for our Eastern anchor; and the new chain was of sufficient length to allow thirty-five fathoms for the western anchor, and five fathoms to turn up for a bridle; which, together with the five fathoms of bridle, and the swivel, which we had left, would be very sufficient for our purposes. Our seamen therefore were ordered to go out the next day, if the weather suited, to make one more trial at dead of neap, when the tides run less rapid; and if unsuccessful, to return in the evening to assist in carrying out the buss: this indeed once more proved to be the case; so that every thing being ready, we went on board her the 1st of July in the evening, and weighed. The wind being then at north, was very fair for carrying us out; but before we cleared the Sound it began to freshen to a stiff gale, it therefore became necessary to consider, as our vessel would not turn to windward, how we were to get back, in case we should by any accident be prevented from mooring. We therefore came to an anchor in Cawsand Bay; and as in the evening it became very moderate, though from the same quarter, we weighed and made easy sail, having the whole night before us; and by three next morning we got out the length of the Edystone. As the tide had overhauled us, and driven us to the eastward of our proper mooring-place, we let go an anchor and warped the buss to her proper birth: but before we could ground our western anchor, the tide of ebb set so strong as to carry us too much to the west; we therefore desisted for the present, till the ebb abated, and landed on the rock, unloaded the Edystone boat of her cargo, and set a part of it. We returned to the buss about noon to get down our moorings, which we happily completed by four P. M. much in the same manner we had originally done § 142; our eastern anchor lying amongst the rough rocks in fourteen fathoms, and our western in sixteen fathoms water; the house bearing by the compass S. W. by W. distance about 200 fathoms.—And here I must observe, that one misfortune frequently becomes a consolation for another; for if none of those accidents had befallen us, if our buss had kept its station and all our essentials had duly performed their duties, we could have reaped little advantage from them; for we had repeatedly experienced that the progress of the work was by no means proportioned to the length of time that the buss continued at her moorings; so that, from the time of our first going out with the buss to this day, winds, ground swells, and seas, had afforded so few opportunities of forwarding the construction, to any material purpose, that in fact we had lost little or no time; and our principal sufferings were from that vexation and trouble of mind, which such disasters are apt to produce.

267. FROM the 2d to the 5th inclusive we began and finished the Xth Course; and by noon on the 6th we had set the center, and two of the surrounding stones of Course XI; I therefore left Mr. RICHARDSON and company to proceed; and, as the method was the same as has been particularly described in the course of last year's work, there will be little further occasion to trouble my reader with any account of the building work; except to mark its progress, with the incidents attending, and such alterations in the method, as were necessarily occasioned by the different modes of construction, which the different purposes naturally required.—Our present run of fine weather was not lasting, for though we completed the Xth Course in four days, it was not till the 18th (twelve days longer) that the XIth Course was finished. However, the seamen that were relieved upon the 16th brought word that the buss had rode it out very well, without being under the necessity of veering out any more cable.

268. ON the 17th at midnight I went out, and found RICHARDSON and company at work delivering the Assistant's cargo, that had been on board ten days; and by the 24th the XIIth Course was finished; as was the XIIIth the 5th of August; and on the 8th of that month the XIVth was completed, and therewith the Fundamental Solid.—From hence begins that part of the building, also called the Solid, which includes the passage from the Entry-Door to the Well-Hole for the stairs. The Plates No. 11. Fig. 2, 3, and 4; together with the Section No. 9, will explain, by inspection, the construction and proportion of these parts much better than words; I shall therefore think it sufficient to say, that as, for the sake of the well-hole, we must necessarily lose our Center Stone, the four stones surrounding it that in the former courses were by four dovetails united to the center stone, were, as now prepared, to be united to each other by Hook-Scarf-Joints, so as to compose, in effect, one stone: and as, in consequence, we had also lost our center cubes, it became expedient, that the work might have an uniform texture and strength, that those four stones, making a complete circle for the stair-case, should be provided with cubes to prevent their being shifted by any shock applied horizontally, (see Fig. 4.) as well as with trenails to hinder them from lifting. By this means the principle of consolidation would be effectually preserved: but as the top of the XIVth or Entry-door Course, was twelve feet above the top of the rock, that is, twenty feet four inches above the base of the 1st Course, the stroke of the sea must here become less violent, and therefore a less degree of resistance would be equally sufficient. And as the large cubes would too much cut the work, which was here of considerably less area; and as several cubes would be requisite for the Well-Hole Stones, I had determined, above the Entry-door Course, to increase the number of cubes from eight to sixteen, and to diminish their size from twelve to six inches; but still to be of solid grey marble, and two of them to be introduced into each of the four well-hole stones.

269. UPON the 9th of August at two A. M. I landed on the rock, and marked out the Entry and Stair-case; and having unloaded the Edystone boat, which was loaded with the first pieces of Course XV. we immediately proceeded with it; and from this time were blessed with such an uninterrupted continuance of fine weather, that upon the 20th day of August the XVIIIth Course was completed, which reunites the building into a complete circle by covering the passage to the stair-case: the external face of the stone of that course, which makes the cover or head of the entry door, having the figures 1758, denoting the year in which this part of the work was accomplished, cut, in deep characters, upon it. During this fine season we had however one accident, that might have proved of bad consequence, if Providence had not interposed. Upon the 15th, while all the people were at work upon the building, and the yawls attending in the Gut, by some accident the hook by which the in-hauler guy of the shears was attached, became undone; and in consequence the shears came forward, upset into the Gut, and falling upon one of the yawls considerably damaged it, and hurt two of the workmen, so that they were obliged to be sent home to the care of a surgeon; but they were soon recovered, and returned to their work with their company the next turn.

270. ON the 24th of August the fine weather, and in consequence the works, were interrupted, the XXth Course being then in hand; and it was not till the 24th of September that,



with every possible exertion, the XXIVth Course was finished; which completed the Solid, and composed the floor of the Store-Room.—During this month of froward weather, it happened upon the 30th that the men, who went in the yawls to help the Assistant out of the Gut, after so doing, the wind becoming fresh at E. with a strong tide of ebb, were not able either to get on board the buss, or land upon the rock; so that those remaining upon the rock could not get on board the yawls: those in the yawls were therefore under the necessity of lying upon their oars all night, in the wind and rain, to the leeward of the building; those upon the rock amused themselves with their work; which, having their lanterns and candles, they were enabled to do. On the morning of the 31st the wind abated, and they got happily off without any other harm, than that there was not a dry thread amongst the whole company. This was the first and only time that either company were ever detained upon the rock: and, considering the number of escapes we had had, it was rather surprising that this had not happened oftener.

On Wednesday the 6th of September it blew a storm, and when I landed on the 8th I found the forelock, which fastened the foot of the south leg of the shears, broken, and the two legs driven together: but the house being now almost as high as the top of the shears, the in-hauler guy tackle had been hooked to a lewis in the floor of the top of the building, which supported the shears from falling, otherwise they must have been destroyed, as happened before about the same time last year. (See § 248.) No other part of the tackle however had received any injury.

271. IT being, as said, the 24th of September when we finished the solid, had nothing been further in view than the completion of the building the next year, I certainly should have been very well contented now to have put a period to this year's work; but, conceiving it would be of great utility to the public, I had been for some time past meditating upon the practicability of exhibiting a light from the house during the ensuing winter, provided we could get the Store Room completed; of which I thought there was little doubt, when I considered how much less of solid stone was necessary to raise one room with its vaulted stone cover, than was necessary to finish as much in height of the solid; and that for the execution of this, every thing was ready in the yard for putting together.—Accordingly, upon the 28th of September I wrote to the proprietors; and also gave an account of the advancement of our works to the Board of Trinity House; intimating the practicability thereof, in case I could get the Store-Room completed: and also the probability of doing it, as it certainly could be effected in eight or ten days of working weather. I also set forth the general outlines of the method, by which I proposed to do it; which was, that besides making good the stone floor above the store-room, a strong platform of timber was to be laid over all, and that covered with a Tarpaulin well secured down. Upon the middle of this platform I proposed to set up our triangle, wherewith we hoisted and set our stone; the legs to be well lashed down, and to suspend the Lantern thereon that was made for the Neptune Buss; and, as nothing would project beyond the circumference of the area of the top of the building, the lantern being in the center would be effectually screened from the stroke of the sea; and every thing would be sufficiently strong to resist the falling broken water, which would immediately shoot off from the platform: and as I meant to lay three floors in the well-hole, I could convert the whole of that cavity, as well as the passage, into store-rooms, so as to make sufficient conveniency for two men, which appeared to be all that was absolutely necessary for the keeping a light.—As I doubted not but this proposal would be approved, and there was no time to lose, I went on with it in the same manner as if I had received an order for that purpose; and I not only got prepared the wooden platform and tarpaulin, but fixed with two of my hardiest workmen to keep the light for the winter; which for double their constant wages they agreed to undertake: and as, under these circumstances, our platform would be full forty feet above the base of the building, and every thing very substantial, I did not doubt but that my two men would fare much better in the year 1758, than Mr. WINSTANLEY's did in 1698; and quite as well as Mr. RUDYERD's could do in the year 1708\*.

272. THE 25th and 26th of September Course XXV. being the first course of the super-structure, was successfully completed in its place; but as the mode of construction now became

\* See Mr. Winstanley's account § 20 and 21; and Mr. Rudyerd's § 34 and 36.

entirely different from the former, it becomes necessary to give an account thereof, as also of the reasons for the change. The building was carried up solid, as high as there was any reason to suppose it exposed to the heavy stroke of the sea, that is to thirty-five feet four inches above its base, and twenty-seven feet above the top of the rock, or common spring-tide high-water mark. At this height, as it was reduced to sixteen feet eight inches in diameter, it became necessary to make the best use of this space, and make all the room and convenience therein that was possible, consistent with the still necessary strength.—The rooms being made of twelve feet four inches diameter, this would leave twenty-six inches for the thickness of the walls. These being made with single blocks in the thickness, so that sixteen pieces might compose the circle, would, from its figure, compose a stout wall; yet moorstone, as has been observed, being a tender kind of stone in respect to the union of its component parts; any method of dovetailing the blocks together at this thickness, appeared to me impracticable to any good purpose. What seemed to be the most effectual method of bonding the work together, was that of cramping with iron, which would confine each single piece to its neighbouring piece in the same circle: and if to this be added, that every piece should, at each end of it, lay hold of an inlaid piece, or Joggle, in the same nature as the cubes, then not only all the pieces in the same course would be united to each other by the cramps, but steadied from moving upon the under course by the joggles, and of consequence would be fastened at thirty-two points; for, in each course there being sixteen joggle stones, as each end of each principal piece, at its base, took hold of half a joggle, there would be thirty-two points of confinement in the circle above; that is, the joggles being made to occupy the middle of the upper bed of each block; in that situation they would cross the joints of the course above. These joggles, as well as the rest, were of sawn marble, and made eight inches long, four inches broad, and three inches thick: each end of each block therefore would occupy four inches in length, four in breadth, and  $1\frac{1}{2}$  inch in the height of each joggle; and this I judged quite sufficient to keep every course in its place, at the height that this kind of work was begun, and so as to constitute a piece of solid masonry. There was however another matter, that it seemed quite material also to attend to; and that was, to render the habitable rooms contained within those shells of walls, perfectly dry and comfortable in all weathers; and this was a matter that seemed to merit very particular attention; for the seas that are said to rise up against, and in a manner to bury the house in time of storms, (see § 21.) would make effectual trial of every joint.

The level joints being pressed together by the incumbent weight of the building, would keep firm and sound that cohesion of parts produced by the mortar; so that being once made watertight, there was no doubt but they would so remain: but with respect to the upright joints, the least degree of shrinking, either of the stone or of the mortar between, tended to open the joint, so that it might always remain leaky in a greater or a less degree; for we know of no degree of separation of parts, however minute, short of absolute contact, which will stop or prevent the percolation of water. For this purpose I conceived, that if flat stones were introduced into each upright joint, so as to be lodged partly in one stone, and partly in its neighbour; much upon the same idea, that Dutch laths were formerly introduced into the joints of chamber floors, to hinder the passage of wet; the water might be prevented from making its way through the upright joints of the walls.

The manner in which it was executed was as follows, (see Plate No. 11. Fig. 6.) At each end of each piece of stone, answerable to the middle between the inside of the wall and the outside, was sunk a groove 2 $\frac{1}{2}$  inches wide and three deep, running from the top to the bottom: when therefore two contiguous pieces of stone were put together in their places, the two grooves being applied to each other, they would form a Rhomb of six inches in length, and 2 $\frac{1}{2}$  inches in breadth, which in this state would be an unoccupied cavity from the top to the bottom of each course; the rest of the joint, where the surfaces of the two stones applied to each other, was made good with mortar in the ordinary way, and brought together by the gentle blows of a beetle. For the groove mentioned, a solid Rhomb was prepared, of about two inches thick by five inches broad, and in length a little less than the depth of the cavity, which generally was eighteen or twenty inches; and for the sake of firmness of those slender pieces of stone, I made choice of the flat paving stones from Purbeck, which, as mentioned § 116, is a laminated marble of great strength and solidity. The Joint Stones (which was the name we gave those Rhombs) thus prepared, would readily

go down the cavities; but to fix them solid, a quantity of well-tempered mortar was prepared, made more soft than ordinary, by the addition of a little water; a competent quantity being put down to the bottom of the hole, the joint stone was put down upon it; and, by the simple pressure of the hand, was forced down to the bottom, causing the semifluid mortar to rise up to the top, and completely fill the cavity: and when forced down in the way described, having in this state a small quantity of superfluous moisture about it, a few very gentle blows or raps were given upon the top of it by the handle of a mason's trowel, which producing a small degree of agitation, while the dry stones were absorbing the moisture, contributed (like the beating of mortar) to bring all the parts into their most friendly state of contact, and in consequence, to their firmest state of union; and this happened in the course of a few minutes, so that no further agitation could be of any service.

As the cramps, that were to bind the contiguous pieces together, must cross the joints upon their upper surface, they were of course to be applied after the joint stones were settled in their places. Precaution was therefore necessary not to apply too much exertion in forcing down the joint stones: for, however gentle the operation may appear, according as it has been described, yet it was found advisable not to put in the joint stones till an additional piece had been got down upon its joggles, and plain jointed, at each side of the two pieces, whose joint stone was to be put in; for by this means there were the united efforts of all the joggles, and adhesion of the beds, of two stones on each side of that where the effort was applied. Without an attention to this, the lateral force arising from merely pressing down a joint stone, was capable of breaking the adhesion of the joint where it was applied.

273. THE cramping was applied the last thing. The top or flat bars of the cramps were about thirteen inches long, two inches broad, and  $\frac{5}{8}$  of an inch thick, and were turned down at each end about three inches in length; forming a cylinder of  $1\frac{1}{2}$  inch diameter. Jumper holes were previously bored when upon the platform, and the cramps fitted to their places; the surface of the stone under each cramp being sunk  $\frac{1}{4}$  of an inch, so that the two stones together would completely receive, or rather bury, the cramps: the joint stones, as said above, being made so much shorter than the height of the course, as not to interrupt the bedding of the cramp. The places for the cramps being properly fitted and cleared (as we now were not liable to be driven off the work in a moment, as had formerly been the case) we took the opportunity, whenever time allowed it, of fixing the cramps of a whole course together. There was no danger of the cramps not fitting; as, besides that all the cramps were forged to fit a gauge-bar having a couple of holes at the assigned distance, they were also fitted and marked to their particular places at Mill Bay, while upon the platform.—Every cramp being now ultimately tried to its place, it was then put into a kettle of lead made red hot; and the cramp continued there till it was also reddish. About a spoonful of oil was poured into the two cramp-holes, and the cramp being put into its place, the ebullition of the oil caused by the heat of the iron, quickly gave a complete oily surface, not only to the whole cramp, but to the whole unoccupied cavity in the stone; then the hot lead being poured upon it, the unctuous matter caused the metal to run into and occupy the most minute cavity unfilled, and completely to cover each cramp; and they became by this means defended from the salts of the sea, even had they remained uncovered, upon Mr. RUDYERD's principle\*: but as every cramp, from construction, would be covered by the middle of the base of the stone in the next course above, it became defended from moisture in the most effectual manner possible; and thus by cramping in general a whole course together, the contraction of the iron in cooling would greatly add to the tightness wherewith every stone was bound to its fellow.—Thus, according to this mode of fixing, (besides the union of the parts by the mortar itself) to resist all violence and derangement whilst it was doing, and before the induration of the mortar, every course was retained in its place by sixteen joggles, and each single stone by two half joggles at its lower bed; they were further steadied to each other by the joint stones, and lastly by the cramps, which completely prevented a separation; and this method proved so effectual, that we were not only free from all derangement of the stones, when in their places, but I

\* § 37. It is there said that instead of Lead Mr. RUDYERD had used coarse Pewter. The lead we used was slag Lead, which is harder and stiffer than fine lead: and as we used no cramps, as an essential part of the building, till above the store-room floor, I judged pewter, merely for the sake of stiffness, there to be unnecessary.



did not find a leaky joint, except one, in the whole building. By a due consideration of Plate No. 11. with the particular references to it, the whole of this process will become perfectly intelligible.

274. ON Saturday the 30th of September, Course XXVIII. was completely set; and being the first course, upon which was rested the vaulted floor, which made the ceiling of the store-room and floor of the upper store-room; and, as here again occurred a difference in the mode of fixture, in this, as in all like cases, I attended the performance of the work: and that was the leading in of the first circular chain, that was lodged in a groove cut round the middle of the upper surface of this course; which this day was satisfactorily performed; and the next day, Sunday October the 1st, Course XXIX. was set, and its circular chain leaded in also; which operation, with the reason thereof, it will be proper here to describe.

The ordinary way of fixing the several courses by joggles and joint stones; and also the bonding them together by cramps, has already been described; but those courses, upon which the floors rested and depended, seemed to demand every possible security.—It will be seen in the general section, Plate No. 9, that each floor designedly rested upon two courses: it will also appear, by inspection, that the circumference of the floors was not made to rest upon the sloping abutments of an arch, in lines tending towards the center of the sphere, of which the under side of the floor was a portion, but it rested upon a triple ledge going circularly round the two supporting courses. In consequence of this, had each floor been composed of a single stone, this lying upon the horizontal bearings furnished by these ledges, would, while it remained entire, have no lateral pressure or tendency to thrust out the sides of the encompassing walls\*: and that, in effect, the several pieces, of which the floors were really composed, might have the same property as whole stones; the center stone was made large enough, to admit of an opening, from floor to floor, or Man-Hole, to be made through it; and being furnished with dovetails on its four sides, like those of the entire solid, it became the means by which all the stones in each floor were connected together; and consequently, the whole would lie upon the ledges like a single stone, without any tendency to spread the walls. But, if by the accident of a heavy body falling, or otherwise, any of those stones should be broken, though this might not destroy its use as a floor, or its properties as an arch; yet the parts would then exert their lateral pressure against the walls: and therefore, as a security against this, it became necessary that the circle of the inclosing walls should be bound together, and the building, as it were, hooped.

This would be in a great measure brought about, by the cramps tying the neighbouring stones together, as already described for the ordinary courses; but yet this was no absolute security, because the outside stones might break and separate, between cramp and cramp: and I suppose it was for reasons of this kind, that Sir CHRISTOPHER WREN, in the construction of the Cupola of St. Paul's, did not chuse to depend upon cramping the stones together, of the course that served as a common base to the inside dome, and the cone for supporting the lantern; but chose to surround the whole with continued chains of iron†.—Upon this principle, an endless chain was provided for each of the two floor courses, see Plate No. 11. Fig. 7. The bars composing the links being 1½ inch square; that the most iron might be included in a given space, the corners only were a little canted off; and the double parts being brought near together, the whole was comprehended in a groove, of somewhat less than four inches wide, and as much in depth; into which the chains being introduced and brought to a stretch, the rest of the cavity was filled with lead; of which each took about 11 cwt.

Had the author of the Parentalia informed us particularly how this was done, it would have been useful to me to have known it. It is obvious that it must be in a manner impracticable to heat chains of such a length as even ours, in the manner I treated the cramps; or that the whole of the circle could be run at once: because if so attempted, the metal first poured in would have

\* This method of abutting by ledges also prevented the shell of the walls from being unnecessarily thinned by a longer continuance of sloping lines.

† “Although the dome wants no buttment, yet for greater caution it is hooped with iron in this manner. A channel is cut in the bandage of Portland stone, in which is laid a double chain of iron strongly linked together at every ten feet, and the whole channel filled up with lead.” WREN's Parentalia, p. 294.

so far to run, that one ladleful would cool and set, before another could be put down upon it; so that the mass of lead, instead of enveloping the iron of the chain, as one solid piece, and thereby excluding all moisture, would in many places be composed of *Laminæ* without any firm cohesion.—In our work, it was performed in the following method. The chains were oiled all over before they came from the shore; and the circumference of the groove was divided into four parts by stops, or dams of clay; to prevent the lead from flowing further than one quarter at a time. A couple of iron kettles were provided, capable of melting commodiously, when full, six cwt. of lead each; and that quantity was brought in each to a full red; that is, somewhat hotter than we used for the cramps, as the iron of the chain as well as the stone were cold. The whole quantity of lead being brought to a heat that we judged proper, and the quarter groove being supplied with oil sufficient to besmear the whole surface, two persons with each a ladle, as briskly as they could, poured the melted metal into the same quarter of the groove; and as soon as it was full, and the lead began to set, one of the clay dams was removed, and the melted hot metal was poured upon the end of the former mass, till it was perceived to re-melt and unite with the fresh metal. This done, the dam at the other end of the first run mass was taken down, to prevent its cooling more than was necessary, and the third quarter was treated like the former; the end of the mass rendered solid by cooling, being re-melted by the fresh hot metal: lastly, both the remaining dams being taken down, and the metal at each end having a considerable heat, it was found practicable to dissolve both the ends of the former masses; first applying both ladles to that which had had the greater time to cool, and afterwards to the less: by this means the whole was brought to a solid consistence, and the chain entirely buried in the lead.—It is however to be remarked, that to preserve proper impressions in the lead, for the joggles of the course above, those impressions were made by confining down bricks in proper places, which when removed, the proper marble joggles were set with mortar in their places.—Thus the floor courses were in effect hooped; and the hoops securely protected from moisture and rust; first by a coat of oil together with a body of lead; and secondly by the whole being lodged in the middle of the wall.

Some may perhaps think this extreme precaution of the chain courses, and the forming of the floors upon a system of dovetails, might have been dispensed with; and probably it might, if the whole of this work must have been executed upon the Edystone Rock; but it is to be remembered that the iron chains were executed on shore, at so much per cwt.; were fitted to their places in the work-yard at Mill Bay; and the extra work in the jointing of the floors was the produce of so many days work of a stone-cutter in the same place: so that little extra expence attended the fixing at the rock, except a little more Lead, and a little more Fire.

275. MONDAY October the 2d we proceeded to set up the centre, composed of sixteen ribs, (see Plate No. 18. Fig. 3.) for putting the floor together upon; but I must here note, that having the evening before had the opportunity of landing the five large stones composing the middle of the floor; those were, previous to the setting up the centre, got up upon the top of the wall; for all the rest could be got up through the man-hole left in the middle of the centre, answerable to that of the centre stone; and this afternoon we landed all the remaining pieces belonging to the floor, being in the whole thirty-seven; which we lodged in the well-hole for the stairs, and in the store-room under the centre. This I was not a little anxious to get done; for we had now got into the building every piece of stone that I had it in view to set this year, as necessary for the establishment of a light; but this solicitude had nearly cost us our boat the *Weston*; for though the past week had been the finest this season, yet before the boat could be got out of the Gut, it began suddenly to blow so fresh at E. that it was not without the greatest difficulty and exertion, that she was got out of it without damage.—Being myself wanted at Mill Bay, to forward our equipments for rendering the house habitable, I returned in her to Plymouth; and, as rough weather came on, I got that work well advanced. I went out again on Thursday the 5th, and saw the two first stones of the floor set in their places in the outward circle\*; but after doing this, we had some risque and difficulty in getting aboard our yawls. The company before my

\* In setting the floors we begun with the outward circle of stones, because at all adventures they were to fit the outside shell of the building; and if set last they would not have gone into their places.

arrival had employed themselves in getting down the windlass and shears, as having no further occasion for them this season.

The weather continued broken till Saturday the 7th, on which day the Edystone boat came out, having on board the roof or platform, for covering the building, and protecting it, as mentioned, from the entrance of the downfall spray; together with the doors, iron-work and timber for fitting up the same for habitation; Coals, Water, &c. and the carpenters for fixing those temporary works. This afternoon we landed, and went on with the setting of the outward circle of floor stones, made the holes in the wall for fixing the hinges of the entry and store-room doors; and did not doubt but that one favourable day, would enable us to complete this floor; and then we proposed to begin directly to lay on the Platform roof; which would be perfected in two or three hours: and as this being done would render the building water-tight; we then intended immediately to make a lodgement therein, and go on to the entire completion of this temporary part of the work; however, towards evening, while we were proceeding, a ground swell began to come on, and to such a degree as reminded us of the necessity of retiring, though two stones were wanted to complete the outward circle (see Plate No. 11. Fig. 7.); and as the sky began to look foul-weather-like, I endeavoured to see every thing put into the best posture for receiving a storm. In particular, I caused the middle stone to be laid upon the centre, by way of weight, to keep it steady. Three of the four stones that were to connect with the centre stone were laid upon the top of the wall on the N. E. side; and the fourth I caused to be hoisted and suspended upon the triangle, in the posture that is shewn Plate No. 14. at Stage 2nd. So, that the triangle, which was all of it completely within the area of the top of the building, would be kept down by the weight of this stone, which was between seven and eight cwt.—The other three that lay upon the wall, I caused to be carefully drawn within the circumference thereof, so that there might not be the least projecting part for the water to strike against in flying upwards; which I judged quite necessary, though the walls were then upwards of forty-three feet above the foundation stone, and near thirty-five feet above the top of the rock. After righting all matters to our satisfaction, we had again an escape in getting into our yawls.

In the night the wind came to S. W. and S. and in the morning the swell was so great as to oblige the Edystone boat to quit the moorings: and as I wanted to be at Plymouth to expedite and finish our intended equipment and stores, which I had greatly at heart, and we were not likely to proceed soon to business, I left orders with Mr. JESSOP for the completing of the floor, and took my passage home in the boat.—The evening of this day, Sunday October the 8th, it blew a storm, the men of war in the Sound frequently firing guns of distress. About break of day on Monday morning the wind suddenly veered to N. W. but it still blew very hard.

276. THIS morning, October the 9th, I went up to the Hoa to look out with my glass; I could just discover the house, and the sea breaking over it, so as at intervals entirely to bury it, but could discover nothing of the Buss; however, the air being very hazy, the hull of that vessel being low, and its mast a small object, I judged that to be the reason I could not see her.—In the afternoon, the air being somewhat less hazy, I looked out again; the sea was breaking over the house as before, but still no buss was to be seen, which created some apprehension for her and the people.

Tuesday October the 10th I again went up to the Hoa, and though the wind had remained fresh at N. W. now above twenty-four hours, yet the sea was still breaking over the house, rising up in the form of a white pillar, considerably higher than the building, and of such magnitude as at times to intercept every part of it from view: but the air being now more clear, in the intervals of its retreat, I could distinctly perceive the triangle standing upon the house, and the stone suspended thereon; but to my great mortification, found that the buss was really gone from her moorings, and no where to be seen.—This, in reality, turned out a day of thorough regret; for, besides the uncertainty of the fate of the Neptune Buss, it brought me the resolution of a General Court of the Corporation of TRINITY HOUSE, upon my proposal of the 28th of September, for the exhibition of a light upon the house during the winter; which more effectually put a stop to all further attempts to proceed this year, than the parting of the buss from her moorings. Their answer was to this purport: that having taken into consideration the proposals (mentioned § 271.)



"on reading the acts of parliament, the application from the merchants and owners of ships, the "patent for the floating light, and the inclosed Narrative of the first light-house erected there\*, "they are of opinion, that a light cannot be exhibited on the Edystone rock till the light-house is "rebuilt."—This rebuff, I own, mortified me much, not only that I should in appearance fall short of the expedition which my predecessors Mr. WINSTANLEY and Mr. RUDYERD had shewn, to procure the public a temporary light in the course of the third season; but that my exertions on this head were frustrated†.

277. THIS evening at ten Mr. JESSOP returned to Plymouth, and, to my no small joy and satisfaction, brought me an account that the buss was safe at anchor in Dartmouth Harbour.—He further informed me, that on Sunday, about two hours after I left them, it began to blow a storm at S. S. W. and that in consequence thereof he ordered the decks to be cleared, and every thing put in order; but did not bend the main-sail, because by holding wind, it might be the occasion of their breaking loose. Towards night however the storm increased, and the sea frequently intercepted from them all sight of the building, as the broken column of water rose considerably higher than the top of the triangle: that at night the storm still increased, and about eleven o'clock the cable parted at the Bows.—Upon this they hoisted their fore-sail and mizen, and endeavoured to stand in for the land; but the sea proved so tempestuous, that with the little quantity of sail they had, they could not keep a proper steerage; and it being also excessively rainy and dark, they were afraid of running on shore before they could see it: they therefore determined to lay her to, with her head to the S. E. that they might have daylight before they drove to the land. About two o'clock the wind came to the W. and at break of day they found themselves about three leagues from, and abreast of the Start. They then bent their main-sail, hoisted their Jib, and stood in for the land with the wind at N. N. W. (see the Chart No. 1.); but the Neptune buss was so slow a sailer, that it was four P. M. before they got off Dartmouth: they then, by the help of a pilot, came to an anchor in the Road, and the next morning warped into the harbour; and after seeing the vessel safely moored, Mr. JESSOP and part of the workmen made the best of their way to Plymouth.

Wednesday October the 11th JOHN BOWDEN was sent with one of the seamen over land to Dartmouth; the former to take charge of, and the latter to assist in bringing the buss round to Plymouth, as soon as the wind should prove fair.—This day the wind continuing at N. W. and having become so moderate as to produce smooth water in Plymouth Sound; though I now laid aside all further idea of carrying out the buss to her moorings again this year, we prepared every thing on board the Edystone boat and Assistant to go out with a competent set of workmen the next morning, to do whatever might appear necessary upon the building, after such a trying storm; and at least, if possible, to set the two remaining pieces of stone, that were wanted in the outward circle of the vaulted floor; for that being done, the centre might be taken down, as every circle of stones would support itself: and I was desirous, if it should be found practicable, to do something to secure the Moorings; there being only one buoy, upon one of the anchors.—Every thing was thus prepared, but early next morning there came on a fresh of wind at E. which rendered it to no purpose to attempt to go out.

The wind continued fresh at E. for several days running, and brought home the buss, which was moored in Mill Bay on Friday evening: and on Sunday came on a storm at E. and a continuance of bad weather from the same quarter.—Nothing therefore being necessary further to be attempted, and every thing going on well in the yard under the care of Mr. TYRRELL, I left the necessary orders what to do, in case of favourable weather, and every thing to the care of Mr. JESSOP; and took my departure for London on the 25th of October: after which, no further events, of consequence to this business, happened in the remainder of this year.

\* The narrative referred to was an extract from that of WINSTANLEY, recited § 17 to 27 inclusive.

† It is very possible I might not at that time have reflected, that we heard nothing of any floating light being then maintained; so that till a temporary light was erected upon the Building itself, the public were not served with any light.

## CHAP. III.

CONTAINING AN ACCOUNT OF THE TRANSACTIONS OF THE FOURTH AND  
LAST YEAR'S WORK, TO THE FINISHING OF THE BUILDING  
IN THE YEAR 1759.

278. **DURING** my stay in London, in the early part of the year 1759, I received regular accounts of the proceedings at Mill Bay, which were carried on with all the dispatch I could wish, while I was myself forming and making out the necessary designs for the iron rails of the balcony, the cast iron, the wrought iron, and the copper works for the lantern; which, together with the plate glass work, were all done in London. The weather having continued unfavourable to visiting the works at the Edystone during the winter, I got no report thereon till I received Mr. Jessor's letter dated the 27th of March, wherein he informed me that on the 21st of that month, being the first opportunity he could catch after the violent storm which had happened on the 9th preceding, and which had done very great damage to the ships, houses, and buildings at Plymouth; they put to sea, and at a distance observed the triangle standing, with the stone hanging upon it, as it was left at the conclusion of the last season's work; so that when they had got by the Edystone, and doubted not but to have laid hold of the Transport Buoy, they found it was gone! whereupon they came to an anchor; and getting into the small boats, went into the Gut and landed. They found not only the solid but the hollow work perfectly sound and firm; all the mortar having become quite hard; and in short every part of the work in the situation in which it was left by the workmen in October: the only derangement was, that the sea had carried away the south fender pile from the rock; and also, from the top of the wall, one of the three stones that I had taken care to draw within the verge of the circumference of the wall, as mentioned § 275. That they had found the fourteen pieces of stone set in the circumference of the floor, stuck quite firm to the wall, though two of the pieces requisite to complete the circle were left unset; and that, finding the centre itself quite tight and firm underneath them, they had lowered down the stone suspended on the triangle upon it, and removed from the wall the other two remaining stones to lie upon the centre; and lastly, that they took down the triangle and stowed it away in the well-hole for the stairs: but, on further search, nothing of the buoy that was left upon the mooring chains was to be seen. Mr. JESSOR also informed me, that he had put in hand a new transport buoy, and was preparing a south pile; that he had given the necessary orders for fitting out the buss to sweep for the moorings; and that the XLVth Course was then upon the platform\*.

After this the seamen went frequently out, and often swept for the moorings, but without success; although the proprietors had offered £. 10 as a bounty to the seamen in case they recovered one set of the moorings, and £. 20 in case they recovered both sets.—I then proposed the sweeping with a cord, every yard of which to have a lead upon it like those used for nets, which by sinking into the hollows of the rocks might lay hold of the fluke of an anchor; and thereby ascertain its place, which would facilitate the laying hold of it with a proper pliant sweep rope, as mentioned in the operations of last year (see § 258.) This Mr. Jessor made trial of, and informed me that after a considerable time spent, it had proved ineffectual; so that now, looking upon the recovery of our moorings as hazardous, I thought it time to set about the providing a new set. Accordingly, the 29th of May I ordered forty fathoms of new chain to be made at Blackwall, intending to send it down by land; and this, with some old chain purchased in Wapping last year, which we had then at Plymouth, and was thought sufficient for our

\* This course makes the chain course for springing the arch of the balcony floor, and forms the cove on the outside.

eastern chain if occasion required; I judged would serve our purpose for the present year, in case we could not recover any of the others: and Mr. JESSOP was also directed to look out for a couple of anchors suitable to our purpose.

279. THE casting the corner pillars for the lantern being attended with some difficulties, to which the ordinary workmen in the cast iron foundry at that time were not equal, I was recommended to Mr. PRICKETT, then of Farthing-Fields, Wapping, whom I found equally intelligent and ingenious, and who executed my business to perfect satisfaction\*.—The casting of sash frames of copper, each in one piece, was a difficulty I was desirous to see accomplished before I set out for Plymouth. The inspection of Plates N<sup>o</sup>. 12 and 15, will give my reader an idea of this business as well as the former, especially if he also consults the technical description of those plates.—Those copper frames, consisting of nine panes each, being sixteen in number, were successfully cast by Mr. KINMAN of Shoe Lane; a work which did him credit.—The fitting together of the whole work of the lantern with wrought iron framing, as also the balcony rails, I saw in good forwardness, and left in the hands of Mr. BROADBENT, an Engine-maker, in Piccadilly; of which work he acquitted himself to full satisfaction.

280. DURING this stay in London, I had more than once the honour of attending the Board of Trinity House by their desire, and they were pleased to approve of our methods and proceedings. The latter time, which was upon the 2d of June, was to give my opinion upon a proposal that had been made, and strongly recommended to them by an Optician in London, who proposed to grind all the panes of glass for the lantern of the Edystone to circular segments; so that the whole together should form a sphere of fifteen feet diameter: to this I observed, that it was in reality a method of making an easy thing difficult and expensive, without the least solid advantage. For, the proposer seemed to imagine it needful that the rays of light should proceed from the lantern in right lines in every possible direction; whereas those rays that proceed in an horizontal direction out of the lantern are those alone that are seen from the surface of the sea by distant observers; all the rest either going over their heads into the air, or falling down into the water before they reach them: and as, for the sufficient spreading of the lights, so as not to interfere with each other, it had been found needful to place them in Rings, at two different heights; it would be only that ring of lights which was even with the centre of the sphere, whose rays could proceed perpendicularly through the globular panes; the others above or below, must pass through with a proportional obliquity: whereas the rays proceeding horizontally would pass through the upright sides of the lantern in a direction equally near the perpendicular, whether the light exhibited was high or low. And for this explanation, which fully convinced the Board of the inutility of the scheme, I received the thanks of the Deputy Master, in the name of the body.

281. HAVING left all necessary orders for the works going on in town, I arrived at Plymouth the 22d of June, where I found all the stone-work hewn out, the two courses composing the cove and balcony floor upon the platform, with the balcony rails, and the base or plinth course of the lantern thereon; and every thing in all the forwardness I could expect.—I found that on the 13th instant so violent a storm had happened at Plymouth, that the leaves of the trees and bushes, on the windward side, had been blasted, to the extent of four and five miles from the sea; as I supposed, by the salts thereof being impetuously driven against them. In this storm the Neptune buss had received some damage, but had been got thoroughly repaired, and was then out with the seamen, still in search of the moorings.—Five of our best hands being grown self-important, demanded an increase of wages, without which they would not go any

\* The ingenious Mr. PRICKETT, to whom the Iron Foundry of this kingdom owes much, is still living, and is now master of the Falcon Iron Foundry, near Blackfriars Bridge; which is the very spot where the famous Mr. JONES, commonly called GUN JONES, had his foundry, and there cast the smaller work of the railing that incloses St. Paul's, London; for which he had the contract: but the larger parts of that work were cast by Mr. PRICKETT's father, a relation of Mr. JONES, who had his foundry at the Forest of Dean, in Gloucestershire.



more off to the Edystone. I now judged that as the want of earning a sufficiency of money could be no just cause, the shortest way to restore peace, unanimity, and preserve our original system, was to discharge them; which I accordingly did\*.

Mr. JESSOP and the seamen having now found by experience, the great advantage in point of strength which ropes of all kinds preserved by not being hard twisted; and conceiving that the circumstance of too hard twisting, had been the occasion of the parting of our bridle cable the last season; petitioned that we might have thirty fathoms made on purpose for us, and laid quite pliant; in consequence of which we might also increase its strength by a number of yarns, and yet diminish its stiffness. This I readily agreed to, and accordingly a bridle cable was laid perfectly pliant, though it was  $12\frac{1}{4}$  inches in circumference, that is  $2\frac{1}{2}$  inches more than the former.

The old chain before mentioned, which upon the strictest examination was found very sound and good in general, and every link of it, that appeared to have suffered any material waste, having been cut out and replaced with new, was now found to contain thirty-two fathoms complete: a couple of suitable mooring anchors, as also a proper transport buoy, chain and anchor having been provided; all these were put on board the buss; and we now did not want any thing but the new chain from London, which coming by land, we could have the greater certainty of its arrival, which was upon the 2d of July, and it was put on board the buss the same evening†.

282. ON Monday morning July the 3d, at four, I attended the party out with the buss; but, owing to the usual uncertainty of calms, wind, and tides, and the still inherent property of our vessel as a slow sailer; it was not till eight the next morning that we came to an anchor at our mooring ground; yet at three P. M. we had completed this business in the way already described § 142. the west anchor lying in sixteen fathoms water, and the east in fifteen, the rock bearing W. S. W. by the compass, distance by estimation three hundred fathoms. The new chain was our western chain, and the eastern joined it at ten fathoms from the swivel; in consequence so much could act as a bridle in either direction; and to this was bent our new pliant bridle cable. —We then proceeded to lay down our transport buoy; but the wind freshened, and obliged us to desist.

Thursday the 5th of July the wind being at N. W. and moderate; we this morning laid down the transport buoy in ten fathoms water; the rock bearing S. W. by S. by the compass, distance eighty fathoms; which was completed at six. I then landed on the rock with the men; they proceeded to set up the shears and windlass, while I inspected the work; and found, according to Mr. JESSOP's representation, every thing perfectly sound and firm, without the least perceivable alteration since we left it; except that the cement used the first year, now in appearance approached the hardness of the moor-stone; and that used the last year of the full hardness of Portland. By ten the hoisting tackle was fixed, and the spare hands, that were brought out to help with the mooring, returned to Plymouth; and we now proceeded to set the floor, not doubting but to complete the whole of it this day.—The two remaining pieces of the outmost circle, which were left uncompleted last year, were soon set; and we proceeded to haul up the stones for the next circle (No. 4.) from the store-room; but instead of eight, I had the mortification to find that we had but seven, and unluckily the boat was gone home.—It was therefore the likeliest conjecture that the piece of stone wanting, had been driven out of the store-room door; and probably by the same sea that had floated the stone No. 2. mentioned § 278. from the top of the wall: and that this body of falling water, by making its way through the open ribs of the centre, had washed this stone out at the door, though it weighed between four and five cwt. I had no doubt but that it was missing when Mr. JESSOP made his inspection in March; for finding those stones lying upon the store-room floor, piled up much in the same manner as we left them; he had never thought of counting them; not conceiving, but that such kind of weighty materials were very safely lodged in that place, the floor of which is nine yards above the top of the rock;

\* The work being now brought to such a period that it could go on with less interruption, I proposed that this year the companies should change only once a fortnight, which would occasion less loss of time, as well as give more equal opportunities, in having both spring and neap tides in the compass of each turn.

† This chain was forty fathoms, and weighed 36½ cwt.

and the border of the wall rising up as a parapet of defence near eight feet higher.—The disaster of the loss of No. 2. being foreknown, was easily repaired, by making another from the same mould; and which we brought out with us, and landed: the shortest way therefore to overcome this difficulty, appeared to be to send home one of the yawls, with orders, to send out a similar piece belonging to the third floor; and we went on with setting what we had.

Friday July the 5th, we landed upon the rock at four A. M. and, having a very moderate breeze at N. W. I never saw the sea more quiet about the Edystone. We proceeded so as to set two pieces of No. 2. but could go on no further with this part of the work till the arrival of the stone to supply the place of that which had been lost.—We now began to fix up the new south fender pile, which had been washed away in the course of the winter, though fixed with large iron bolts in the firmest manner we could. This was completed at eleven; we then quitted the rock and retired on board the buss, the first time, for want of work.—At noon we espied the Edystone boat about two leagues from us, but the breeze being now from the south, as, it has been observed, generally happens in the middle of the day in fine weather, we sent the remaining yawl well manned to bring out the wanting piece, which arrived this afternoon, and in the evening was set, with several others. On Saturday morning we landed at four, and soon set the two remaining pieces, which finished the first floor. We then cleared away the centre, and sent it on board the buss.

283. HITHERTO we had got up our stones by first landing them into the entry-door from the rock shears, as we had used from the beginning; and after that hoisted them up the well-hole, by a tackle upon the triangle, by hand; but on finishing the vaulted floor over the first room, many of the pieces of stone of the superstructure being too large to go through the man-holes in the centre of the floors, I contrived and got prepared an additional pair of shears, which being placed upon the top of the work, would of course be made to rise with it. The idea of this kind of shears will be formed by inspecting Plate No. 14. at the third stage; which we now set up, and applied accordingly. In this way the stones were hoisted from the boats, as high as they could be, upon the rock shears; then a tackle depending from the top shears just mentioned, hooked hold of the pieces, and hoisted them up to the top, on the outside; and to facilitate this second stage of hoisting, as the work was gradually becoming higher and higher, and the hoisting with tackles by hand not attended with expedition, (see note on § 248.) a temporary windlass for working it, was fixed in the store-room, as is shewn in the same plate.—While those things were fitting up, the Weston arrived at noon on Saturday the 7th of July; and in little more than an hour, her cargo, consisting of twelve pieces of Course XXX. of near a ton each, was laid upon the first vaulted floor, without fear of, or finding, the least degree of settlement, though only finished that morning. For this service we employed three men at the rock windlass, and two at the store-room windlass. The Weston had not got out of the Gut, before we experienced a change of weather, the wind beginning to freshen at N. E.; and scarce was the first stone set, before our attending boats became so unquiet in lying near the rocks, that we found it advisable to quit the work; however, having procured some substantial shelter, we now ventured to leave our mortar buckets, tools, and loose materials, stowed away in the store-room, which was indeed a great easement to us when, in consequence of bad weather, it became necessary to quit the rock. As we had now the wind and tide both against us, we had a hard pull with our oars to get on board the buss; which however we happily effected.

The weather being now attended with the usual uncertainty, upon Sunday the 8th of July only five pieces of Course XXX. were set; but having staid till Mr. JESSOP and his company were perfectly versed in the mode of proceeding, I took my passage to Plymouth; having first established, that they should quit the work at nights; for the building being now raised to a competent height, with sufficient shelter to screen the men at high water, in moderate weather; as the day-light now afforded as many hours as the men could possibly hold out to work; and as we had always found one hour in the day to be worth two in the night; it seemed no longer necessary to work by night, except when the unloading of the vessels or other particular services should require.

284. VARIOUS weather prevented the out-company from making any great progress; however, finding, from accounts, that it would be likely to fall to the lot of RICHARDSON's company to lead in the chains of the second floor (he not having done this part of the work before) I determined to accompany them. We sailed on Tuesday the 17th, and after a bad passage arrived at the buss in the evening, and at low water landed with the company. I found the work at Course XXXIII. six pieces set, and four upon the work, unset, but which were scarcely got out of hand, when the swell came on so violent, that we found it difficult to get on board our yawls. The remainder of this course was still on board the Weston, which had taken it in on the 14th instant.—This evening, between ten and eleven, the Edystone boat arrived, having on board a part of the second floor; and brought me a message from Lord EDGECOMBE, that Prince EDWARD Duke of YORK was desirous of seeing the model of the lighthouse. However desirous I might be to gratify the curiosity of his Royal Highness; it yet seemed of still more consequence, that Mr. RICHARDSON and his company, should set right about the work of the second floor; Course XXXIII. being the first chain course thereof.

Wednesday the 18th of July, betwixt three and four, all hands landed, unloaded the Weston of her cargo, and set the remaining six pieces of Course XXXIII. and by noon the first chain was leaded in. This company having therefore now completed one of the chain courses; having set up the centre last year; and learnt the use of the new tackle by the stones just hoisted, and the whole method of proceeding, I took my passage to Plymouth on board the Weston, and arrived in the evening.

285. THURSDAY the 19th of July I carried the model, drafts, &c. to Mount Edgcombe, when the Duke of YORK was pleased to express great satisfaction. I had the honour of dining with, and attending his Royal Highness after dinner to Mill Bay, where the cove and cornice courses being together, with the balcony rails, and two courses of the lantern upon the platform; his Royal Highness was struck with the great strength and solidity of the work; and was much pleased with the machinery for facilitating the operations of the work-yard.—Being now at liberty, and wishing if possible to see RICHARDSON's company put together the second floor; that I might not be disappointed by a calm, in case there was not wind to carry out the Assistant, which was also ready, I hired a six-oared barge; for which, as it afterwards proved, I had occasion. We rowed out at half past two in the morning, and at six I landed upon the rock, finding RICHARDSON and company at work. They had completed the second chain course of the second floor, had got up the centre, and one of the boat's cargoes upon it, ready to begin the arch, which was now immediately proceeded with; and the day being quite serene, a sea breeze going round with the sun, and further cargoes of stone for the floor being delivered in due time, all went on without interruption.

286. SATURDAY the 21st of July, the morning quite fine, the company landed between three and four, and this forenoon the second floor was finished; so that notwithstanding several interruptions from weather, a whole room with its vaulted cover was built complete in seven days.—The above being effected, the company proceeded in course of work; and the entry and store-room doors with their iron work being brought out with the last boat, the carpenter proceeded to fit the same to place; and I set about leading the door hooks into the jambs, the holes for which had been made at the close of last season; but found they had unluckily forgot to send out a quantity of block tin, that I ordered, for the purpose of giving the lead a proper hardness, to prevent their shaking loose; to make, according to Mr. RUDYERD, a coarse kind of pewter. This was a disappointment, as it was one of the operations, the mode of which, I had in view to ascertain by coming out the last time; however, that I might not lose the opportunity, after some consideration the following expedient occurred to me; I melted down all the pewter plates and dishes that we could muster on board the buss, and mixing them with a proper quantity of lead, it answered my purpose; and the fixing of four hooks was accordingly accomplished. The composition I afterwards used for leading those in, was one pound of block tin to three pounds of lead.—The hooks were let into the stone Lewis or dovetail fashion, and were keyed in hot; and, like the cramps and chains, run in with oil; and while hot, the external part of the iron was



tarred over. And, having now seen this work in the situation I intended when I went off, I returned to Plymouth.

287. THE weather being quite fine, and the work going on with every degree of expedition that could be wished, on Thursday July the 26th, I proposed to go out in the Assistant, as I expected to arrive there by the time the third floor was completed. Previous to my departure, the master called-upon me, to acquaint me that the seaman who belonged to his boat, and was to have laid in it all night, was missing this morning: and I dare say my reader, after what has been said on this head, will wonder that the occasion of his absence could possibly have once more happened. Concluding he had been impressed, Mr. JESSOP went out with the master, on board the men of war in the Sound, and found him on board one, from whom we should least have expected such a detainee; and whose Lieutenant refused to deliver him without the Captain's order, who was then on shore. I thereupon found myself under the necessity of waiting personally on the Captain, who very politely dismissed him at my request; but this incident, from the turn of tides, prevented my arrival at the rock till six o'clock the next morning: when, being Friday the 27th, I found Mr. RICHARDSON had finished Course XL (see Plate No. 9.) being the second chain course of the third floor; for which he was fixing the centre. Having seen this done, and the floor begun; having examined what had been done since I was last there, and finding all right; I returned in the same vessel to Plymouth; and on Sunday the 29th that floor was completed: so that in a course of thirteen days two entire rooms with their proper covers were built; and, except six pieces of stone, all by one company.

Mr. RICHARDSON and company were proceeding with the work, when they were relieved by Mr. JESSOP's company on Monday the 30th; having then completed two courses of the fourth room: but this company was less successful, for on Tuesday the weather came on so adverse as to oblige the Assistant to quit the transport buoy, and to come home with her cargo in.—This day, the 31st of July, the copper ball, of two feet two inches diameter, with its neck and air pipes, was perfected at Plymouth.

288. THE weather turning out turbulent, and at best uncertain, it was Monday August the 6th before I thought it necessary to go out again: but at this time the cove Course XLV. being in hand, which comprehended two circular chains, I landed at six in the evening, and found four pieces of this course set; and this evening we set three more; it was not however till ten at night on Wednesday, that this course was got out of hand, by the leading in of its two chains.—This day I was presented, during a considerable part of it, with a Phenomenon new to my observation: we had light breezes at the west, and frequently drifts of thick fog, which, as the sun shone out, presented to us upon the top of the building, a rainbow making an entire Circle, except where cut off below us, by the shaft of the column.

Thursday August the 9th in the morning we set up the elliptical centre, for setting the balcony floor; and the Weston came into the Gut with her cargo; which, though consisting of only six pieces of stone for that floor; yet the wind coming suddenly fresh at east, and the tide rising, it occasioned such a swell in the Gut that she presently began to roll gunnel to, and while the third piece was hoisting, parted her two fasts\* to the eastern rocks, (see Plate No. 14;) so that being now left to the mercy of the east swell driving her against the rocks, she must have immediately been torn to pieces, had it not been for the Fender Piles: upon this accident I ordered both the windlasses to be lashed, the stones remaining in suspension, and all hands to her assistance; and happily got her out of the Gut, without other damage than to the upper works of her Quarter. When she got to the transport buoy, there was such a cockling sea, that she had not rode above half an hour, before the three remaining pieces began to shift their places, which obliged her to get under sail and return to Plymouth.—Having seen the first stone composing the arch of the balcony floor got into its place, and having given Mr. JESSOP directions for proceeding, the wind by this time was become so fresh as to oblige all hands to leave the rock; and I being wanted at Plymouth, to put forward the work of the copper roof of the lantern, I went on

\* Short cables, or hawsers, for steadyng or fastening a vessel, which are proportioned in size to that of the vessel, and the stress expected.

board the Edystone boat, that waited for me under sail.—This day the fog frequently came on so thick that the vessels at the transport buoy could not be seen from the house.

289. MONDAY August the 13th RICHARDSON'S company went out; and the next day, finding the work advancing towards a completion of the main column, upon which would come in course the setting of the balcony rails, I attempted to go out the 15th, but was driven back by stress of weather: however, on Thursday August the 16th, I got out to the buss, landed with the company, and the Weston was delivered of her cargo; and now all the heavy pieces belonging to the cornice being got upon the top of the building; and every thing but what would go through the hatchways or Man-holes in the centre; the moveable shears, that had gone up with us, from the top of the first room, were taken down and sent home.—The interior area of the balcony floor I found completed, and we struck the centre from under it. We now proceeded to set its outermost circle of stones, which finished the cap of the main column, see Plates No. 9; and No. 11. Fig. 9. being parts of the Corona or cornice: and we fitted the windlass in the store-room, so as to hoist the stones of the lantern through the hatchways.

Friday August the 17th the last pieces of the Corona were set, and therewith the main column completed.—I now examined the perpendicularity of the whole building, by letting fall a plumb-line from the centre of the man-hole in the balcony floor to the centre of the bottom of the well-hole, being 49½ feet; and found it to fall a small matter to the eastward of the centre of the well-hole; as near as I could determine it, not more than ¼th of an inch. I then measured the perpendicular heights of the several parts of the building, and found them as follows:

			Feet.	Inches.
The six foundation courses to the top of the rock	—	—	8	4½
The eight courses to the entry-door	—	—	12	0½
The ten courses of the well-hole to the store-room floor	—	—	15	2½
The height of the four rooms to the balcony floor	—	—	34	4½
Height of the main column, containing forty-six courses	—	—	70	0

290. WE now proceeded this day to set up and lead in the balcony rails, and completed them; but having no stone, we proceeded to make the holes preparatory for hanging the Ports\* for the windows; and having brought out a temporary cover for the man-hole of the balcony floor; I this day applied it to use; in consequence of which, when Mr. RICHARDSON had got the ports hung so as to keep the sea from coming in at the windows, he would be enabled to lodge with his company in the house.—The temporary cover of the man-hole was as follows: a short tub of about a foot high was made without a bottom; and the smaller end of it being sized as near as possible to the man-holes of the floors; it was driven into that of the balcony; and by the time it was driven about four inches; the compliancy of the wood to the stone rendered it quite tight; then the rest of its height, forming a border, and standing about eight inches above the floor, would prevent water from dripping into the rooms through the upper man-hole or hatchway; and having also provided another tub, about nine inches deep, having a strong bottom in it, and so much more in diameter than the other that it would, when inverted, cover it; this being applied as a cover, would in the greatest stress of weather defend the building from the entry of water at the top, and this was the same that I intended to have used, to make good the joint within the first vaulted floor, in case my proposal of keeping a light the last winter, had been approved of and executed.†—The Edystone boat arrived with the first course of stone for the lantern, and was unloaded this evening.

Saturday the 18th of August, we all landed in the morning at four, and proceeded to set the

\* Those in a dwelling-house would be called window-shutters; but as they were here made in the strongest manner, with double plank, as the port-holes for ships are closed; being in like manner intended to resist the violent action of the sea, are still (as they used to be) called Ports in this lighthouse. Properly speaking, I understand the openings are the Ports, and the shutters the Port-lids.

† This was intended as an additional security, besides an entire cover or platform of wood, as mentioned § 271.

first course of the lantern ; which being in a course of work, and having left directions with Mr. RICHARDSON for the remaining part, including the stone stairs in the well-hole ; I returned to Plymouth to expedite the work that was wanted to be done to complete the lantern, and arrived there at noon.

291. AMONGST the numberless vexations and disappointments met with in the course of this work, not only from the elements, but from the negligence and inattention of others ; it was not one of the least, that the Carrier employed to bring the work of the lantern by land from London (for no other reason but to obviate the uncertainty and disappointment that might attend the sea), had, to serve his own convenience, left the greatest part thereof at Exeter a week before ; and I found it was not yet come the present week ; which prevented our finishing the last course of stone from the platform, that was to receive the iron sill of the lantern. The Rabbet was indeed rough cut in the stone, and was a plain piece of work ; but, as I had never trusted to any thing fitting at the Edystone, but what at first had its parts brought together at Mill Bay, I did not think it prudent to dispense with this rule, without absolute necessity : for, the fitting or adapting the parts of matter together, comes under no calculation in point of time ; as, from circumstances, much time may be required for the purpose, when little is expected. This evening however the work of the lantern arrived ; which desirable event greatly alleviated the chagrin I had felt.

Tuesday the 21st of August the iron Ground Sill of the lantern, or Cap Sill of the wall, was brought to Mill Bay ; and was tried and fitted to the LIId course, which, being the last, was made ready for going to sea.—This day I thought it proper to write to the Corporation of TRINITY HOUSE, to acquaint them with the state of the building, and therein expressed my hopes that the lantern would be soon completed, if the weather continued moderate, so as to be capable of exhibiting a light in its proper place ; and the house made completely habitable, and proof against wind and weather, without the aid of temporary contrivances.

292. THURSDAY the 23d of August. For some time past I had employed a copper-smith in preparing the copper for the roof, so far as he could do it, without having the iron work to which it was to be fitted. The platform therefore being now cleared from all the stone-work, the upper sill of the lantern was put together upon it ; as also the iron ribs that gave the figure and stiffness to the plates of the roof ; and the copper-smiths began to fit the copper roof thereto ; see Plate No. 12 : it being only necessary here to say, that the plates being of  $3\frac{1}{2}$  lb. to the square foot, and of consequence somewhat stubborn ; to prevent all uncertainty in forming them at their hips to the proper figure, I chose them to be mitre-jointed at the angles ; and this joint being covered with a strip of copper, or saddle-piece, of about three inches in breadth, it was easy to fit it to both plates, and render that easy that otherwise would have been difficult. This saddle-piece was therefore fixed upon the angles with a double row of copper nails ; and the whole being rivetted together, the cupola, when finished, would become one piece, and water-tight, like a boiler.

Friday August the 24th we had the welcome news by one of the boats, that this day Mr. RICHARDSON completed Course LIH. : so that the stone-work was now ready for the reception of the metal part of the lantern ; and also that he was proceeding with the stone stairs.

293. MONDAY the 27th Mr. RICHARDSON and company arrived from the Edystone, and gave account that they had lived in the house ever since the 23d instant, and found it very warm and comfortable ; much more so than the buss's hold and cabin. That he set the last stone of the lantern, being that making the door-head, on Friday the 24th ; and then a part of his hands were employed in fixing and completing the fixture of the iron-work of the window Ports, while the other part were setting the stone stairs : and lastly, that they had put on the cap-stone of the stair-head, and finished every thing belonging to the masonry on Sunday evening the 26th of August. However, when all was done, though all was very quiet within the house, they found the sea so unquiet about the rocks, that the yawls could not come alongside them that evening ; and that it was with some difficulty they quitted their habitation, and got on board the buss this morning.



294. THE progress we had made this season could not fail to animate our further proceedings; for from the 5th of July to the 26th of August, both inclusive, we had completed twenty-three courses, including the greatest part of four vaulted floors, six circular chains, and in the whole 470 principal pieces.—Having brought the work to this desirable state, the next day I dismissed all our masons and tanners, except eight of our best hands, who being used to the place, I kept to assist the joiners, smiths, plumbers, copper-smiths, glaziers, painters, &c. whom it was necessary to take off before we could make an entire finish; and who being new hands unaccustomed to the place, I judged would act with more courage, by having seasoned men amongst them.

295. AFTER this time I was thoroughly employed in forwarding the works of the lantern; but we had very soon a change of weather, so much for the worse that though the seamen were ordered out the 29th, to try to sweep for and recover the moorings we had lost in the course of the two preceding years; an hard gale of wind and rain from S.W. coming on, they were obliged to return without attempting any thing.—During this time, however, an opportunity was taken by the seamen of landing in the house, and of wetting the inside of the rooms all over with water, which I directed to be done, in order to feed and harden the cement, and prevent its drying too hastily; as it was not like the outside, subject to be afterwards wet by the sea: but the weather never admitted of any opportunity of sweeping.

On Tuesday the 4th of September, when the work of the cupola was going briskly on in the yard, the foreman of the copper-smiths was taken so ill that he was obliged to leave his work.—This day I received a letter from the Secretary to the TRINITY HOUSE, dated the 1st instant, acquainting me that the Corporation desired me to inform them of the day I was certain a light could be exhibited in the lighthouse, that they might advertise the same; and that the night I shewed the light I should acquaint Mr. SYMONDS, Master of the Floating-Light, not to exhibit it any longer. To this I answered, that though I had met with some disappointments, yet I hoped the lantern and cupola would be ready to carry off that week; and that I should endeavour to complete the whole with the utmost expedition; and when ready would acquaint the Corporation; and concert a proper signal with the Master of the floating-light, in case access to him should be impracticable. That as the season was advancing, and the weather growing more precarious, it might not be in my power absolutely to fix the day I could exhibit a light, till the day itself arrived: in which case, I supposed it to be their pleasure that it should be done, giving the proper notices that they had directed; but if I misapprehended their directions, I desired not to be left in doubt.

The next day the second copper-smith, with his assistants, finished the closing of the joints at the angles; and, that no time might be lost (wanting the proper workmen), on the 6th I worked myself all day at the cupola, assisting in rivetting on sixteen angle pieces of iron in the inside, in the nature of knee timbers of a ship, for stiffening the plates. When these were in part finished, the second copper-smith was also violently seized with a dry Cholic, in the same manner as the first had been. The next day, he being incapable of proceeding with the work; and I very anxious to get what remained to be done at the cupola dispatched; as it prevented the iron ribs, &c. from being withdrawn from the cupola; I again went to work, along with the third copper-smith; and on Saturday the 8th this part of the business being accomplished, the whole iron frame of the lantern was in the afternoon put on board the Weston ready to go to sea, whenever the wind and weather would permit; it having been invariably bad ever since the first instant.—As there was now nothing to prevent our proceeding to fix the frame of the lantern in its place but bad weather; nor any thing to prevent the cupola from following it as soon as fixed, except the joining of the ball to the neck of the cupola; and finding that the copper-smiths who had hitherto served me were not likely very soon to be effective; I requested another brazier of Plymouth, to lend me a journeyman to complete this part of the work. But such is the amazing narrowness of mind of some persons,

that he positively refused us, though he owned the man could be of no use to him the next day, being Sunday: however, on application to Commissioner ROGERS, he immediately granted leave for the brazier of the yard, to assist us in that, or any thing else we might want. Accordingly, on Sunday evening the copula was got ready for sea, its ball being fitted; but the weather still continued so very bad, that the Duke man of war of eighty guns, having parted her moorings, very providentially drove directly into Mill Bay, and grounded on the soft mud; from whence she was, on tide of flood, got off without damage.

296. IT was not till the 12th instant that we were able to look out to sea further than to supply the seamen on board the buss with provisions: in this interim I received Mr. SHUTTLEWOOD the Secretary's letter, in answer to mine of the 4th instant, informing me, that to remove any doubt which might arise, he was directed by the Corporation to acquaint me, that I was to fix the day of lighting, so as to enable them to give a week's notice by advertisement; and, that I might be certain of the day, proper persons were to remain in the house upon the rock, after the lighthouse was finished, to light it on the day appointed.

297. EVERY thing immediately wanted to the completion of the house being got ready and put on board two of the boats, together with all necessary hands; the morning of Wednesday, September the 12th, at one o'clock, we weighed anchor, in a thick fog, without a breath of wind; a breeze, however, sprung up, and we arrived at the buss at five; but the wind being now fresh at east, neither of the boats could go into the Gut; I therefore took the opportunity of landing in a yawl to inspect the house; and had the satisfaction to find, that all the stone work had been finished by Mr. RICHARDSON and his company in the manner I had ordered it: but by nine o'clock the wind was grown so fresh, and raised such a troublesome sea, that the boats were obliged to return without being unloaded; and, as nothing could be done without their cargoes, I took the opportunity of returning, to expedite what was wanting to be done on shore, leaving the workmen on board the buss.

September 13th. My copper-smiths being still unable to work; this morning Mr. KNIGHTON, the brazier from the King's Yard, began to work upon the copper funnels for venting the smoke from the kitchen fires. The next day at noon the weather became so favourable as to admit the boats to go out, and I arrived in the evening, but still could not land on account of the ground swell: however, all the working hands at low water had taken an opportunity of getting into the house, with their beds, victuals, &c. as they had been directed to do.

298. SATURDAY September the 15th, between three and four in the morning, the Weston was got into the Gut, and delivered of her cargo, consisting of the pillars, sashes, and frame-work of the lantern; and though the turn of the tide made it impracticable to get the Edystone boat into the Gut, yet, as her cargo consisted chiefly of the joiners materials, these being light, were landed by help of the yawls: and now the workmen being established in the house, along with a great variety of materials, every one went to the occupation allotted; to recount the particulars of which, would be equally uninteresting and tedious. —I gave my principal attention to the establishing the frame of the lantern upon a bed of lead, and the screwing of it carefully together; seeing that every joint was filled, and screw covered with white lead and oil, ground up thick for paint; and every crevice so full, that the bringing the screws home made the white lead matter to ooze from every juncture; thereby to exclude all wet and moisture, and so as to prevent the iron-work from rusting. To this purpose I took to my aid ROGER CORNTHWAIT, one of the most alert of the masons; this being in reality, after the parts were fitted together by a smith, more the subject of masonry than that of smith's work.—The attention of Mr. JESSOP was chiefly confined to the other artificers: and the rooms being so much encumbered with materials and stores, that there was scarcely room for the workmen; he and myself, as the weather was now promising, went to our former lodging on board the buss.

299. SUNDAY September the 16th was remarkably fine; so that by the evening the whole frame of the lantern was screwed together, and its ground-sill was rested upon a bed of lead; which was done in the following manner. The whole frame being screwed together, was raised from its bearing upon the stone about  $\frac{1}{4}$ ths of an inch, by a competent number of iron wedges; and adjusted by them to an exact perpendicular. Both the stone and the iron were taken care to be oiled before they were applied to each other; and one of the eight sides, having its wedges withdrawn, was run with hot lead; and making a place for it to overflow, as much could be used as would competently heat both the iron and stone, to bring them to a close bearing with the lead; then on the lead's cooling, as the frame became supported on one side by the lead, the wedges of a second side were withdrawn, and treated in the same manner, and so successively till the whole rested upon a solid basement of lead. It was not supposed that the succeeding mass could be sufficiently heated to re-melt the ends of the parts already leaded, as in the case of the chains; but being heated so as to bring them to a close contact, this I judged sufficient, as the lead so applied had no other intent but to bear weight, and give the frame of the lantern one solid uniform bearing.

300. MONDAY the 17th. This morning was also exceedingly fine; and the Weston being in sight, which was appointed to bring out the cupola, we began to set up our shears and tackle for hoisting it. This perhaps may be accounted one of the most difficult and hazardous operations of the whole undertaking; not so much on account of its weight, being only about 11 cwt. as on account of the great height to which it was to be hoisted, clear of the building; and so as, if possible, to avoid such blows as might bruise it. It was also required to be hoisted a considerable height above the balcony floor; which, though the largest base we had for the shears to stand upon, was yet but fourteen feet within the rails, and therefore narrow, in proportion to their height. The manner in which this was managed will in a great measure appear by the representation thereof, in Plate No. 14. (see the uppermost stage); but is more minutely explained in the technical detail of that plate.—As the legs of the shears that had been used upon the rock would have been in the way of the cupola, they were now removed, as being done with there, and were used as a part of this machinery.—About noon the whole of our tackle was in readiness; and in the afternoon the Weston was brought into the Gut; and in less than half an hour her troublesome cargo was placed upon the top of the lantern without the least damage.—During the whole of this operation, it pleased God that not a breath of wind discomposed the surface of the water; and there was the least swell about the rocks I had observed during the season.—This work did indeed require good weather, and we had it; or otherwise we must have postponed it, till it had at least seemed promising; but yet we were prepared for something otherwise than perfect tranquillity: for, besides that our shears and tackle were so well lashed down and stayed, that it was not a small blast of wind that would have carried them away, I had it in contemplation (if it had been needed) to have appointed a couple of men to go up upon the cupola, with staves in their hands, who could, in moderate weather, have defended it from the wall.—This evening the cupola was so far got fixed, with its screws, that the tackle was cast off from it: but this was scarcely got done before the wind began to blow fresh at E.

Tuesday September the 18th, in the morning, the wind was at S. E. with intervals of thick fog; however, betwixt those, I had the satisfaction, with my telescope, to perceive the Edystone boat, on board of which I expected the Ball to be; and which being double gilt\*, I had ordered the carriage of it to be carefully attended to. The wind and tide were both unfavourable to the vessel's getting soon near us; therefore, being desirous to get the ball screwed on, before the shears and tackle were taken down, one of the yawls was dispatched to bring it away. This being done, and the ball fixed, the shears and tackle were taken down, which took up nearly as much time as was employed in setting them up; that is, near twelve hours each, in the whole, to do the work of an hour.—I must observe, that by choice, I screwed on the ball with my own hands, that in case any of the screws had not held quite tight and firm, the circumstance might not have been slipped over, without my knowledge; being well aware, that even this part would at times come

\* The leaf gold was made on purpose, being four times the ordinary thickness; besides which, after the first coating of gold was on, a second was laid upon it, with a view to make it as lasting as possible; and over all a coat of Amber Varnish.



to a considerable stress of wind and sea; and which could not be replaced without some difficulty, in case any thing should fail\*.—I now looked upon it that we might think ourselves secure of finishing the lighthouse this year.

By this time the joiners had set up and completed the three cabin bedsteads, (for their plan, and position betwixt the windows, see Plate No. 11. Fig. 8.) The house being now less encumbered, the morning of Wednesday the 19th, the wind fresh at E. and the weather threatening to cut off the communication between the house and the buss; Mr. Jessop and I removed our beds and stores into the house, and took possession of two of the cabin beds; which we had no sooner done, than it blew so hard, that the yawl was obliged to leave us, and retreat to the buss.

301. ON Friday the 21st all the copper sash frames were got completely fixed in, and ready for receiving the glass. In this work we were somewhat retarded; for the carrier that brought down the work of the lantern (besides disappointing us in time) having carelessly laid very heavy things upon the boxes that contained the sash frames; by the continual working of the carriage, two of them had been broken; and though I got them carefully repaired at Plymouth, yet I judged it expedient to order two new ones from London in readiness, which might at any time be changed for the others, if they happened to fail; but (on account of the late bad weather) these new ones coming, so as to be sent out to us before it was necessary to put them in, I set Mr. Jessop to drill, screw, and fit the new ones, which occasioned the loss of time just mentioned. All the sash frames, in like manner as the iron work, were screwed in with white lead and oil; as I judged that the best means, not only of preserving the work, but of keeping out the wet.—This day the Weston brought out two glaziers and two copper-smiths; they spoke with us, but it blew so hard a gale that they were obliged to return.—On Saturday the Weston came out again, and brought only one copper-smith, the other having been taken ill of the same distemper, which was said to be epidemic; but the wind was still so fresh at E. that there was no landing; they therefore put him and the two glaziers on board the buss.

302. ON Sunday morning the 23d, the yawl came to the house and landed the two glaziers and the copper-smith, with their utensils and materials; the former began to glaze the lantern, and the latter to fit and put up the funnels. This day, with my assistant the mason, I began to fix twenty-four iron cramps; that is, three to each rib of the roof, and which were obliged to be fixed after the roof was together; and being fixed inside, and surrounding the ribs, served to key home the plates of the cupola to the ribs. For this purpose small wood wedges were used, as being more supple, elastic, and compliant than wedges of metal, and therefore more suitable to this particular purpose. This day also the Edystone boat brought out and landed a plumber with his utensils and materials.—The most considerable work for the plumber, was the covering the whole balcony floor with thick plates of lead; and which extended from the top of the plinth, or first course of the basement of the lantern, quite down to the drip of the Corona. They were fitted on separately in sixteen pieces, and soldered together, in place, with strong ribbed joints; and, to prevent the sea from laying hold of them at the drip, and beating them up, they were turned under about 1 $\frac{1}{4}$  inch; and being near half an inch thick, I judged them sufficiently stubborn to prevent being unrippd: I took care myself to put the finishing hand, by batting them closely to the stone underneath, by the gentle blows of a small hammer. In this work the copper-smith assisted the plumber.—Though the joints of the balcony were all very carefully filled and pointed up with our cement, which of consequence would render it water-tight in the common acception of the word, yet this being a level part, the water of the sea beating up in time of storms, would come down with such violence, and in such quantity, upon it; that, to prevent the possibility of the least exudation of moisture down into the rooms, arising either from the calcareous nature of the cement, or any want of closeness in any part of the upright joints, I judged it proper to have this part covered with lead in the manner mentioned, and of such a thickness that,

\* It may not be amiss to intimate to those that may in future have occasion to perform the same operation, that the scaffold on which this was done, consisted of four boards only, well nailed together, at such distances as to permit it to be lifted over the ball when done with. It rested on the cupola, encompassing its neck; and ROGER CORNWALLIS placed himself on the opposite side, upon it, to balance me, while I moved round to fix the screws.

when once done, the wear of the feet, &c. should not produce the necessity of a renewal in many years.

Thursday the 27th, the lead work upon the balcony and corona being now entirely finished, and the cupola completely keyed home to the ribs; the straps and bolts were applied at each angle of the lantern, for screwing it down to the floor of the balcony: but the copper-smith, who had again begun to work upon the funnel, was taken ill, so that he could not proceed; and one of the masons was taken ill also.

303. FRIDAY September the 28th. Since Sunday last the works of the lead and glass were going on very well, the weather in general having been moderate and dry. This day the joiners finished their work, which consisted of the following articles.—Three cabin beds to hold one man each, with three drawers and two lockers in each to hold his separate property, which were fixed in the upper room or chamber. (See plan thereof, Plate No. 11. Fig. 8.) In the kitchen, besides the fire-place and sink, were two settles with lockers, a dresser with drawers, two cupboards, and one platter case. (Fig. 7. of the same plate shews how these were disposed.) In the lantern, a seat was fixed to encompass it all round, the door-way excepted, serving equally to sit upon, or stand to snuff the candles; and to enable a person to look through the lowest tier of glass panes at distant objects, without having occasion to go on the outside of the lantern into the balcony.—Besides the above, the joiners had fixed the ten window frames with their sashes; that is, two in the upper store-room, disposed N. and S. and four in each of the rooms above: all which were bedded in putty, and falling into rabbets cut for them in the original formation of the stone, they could be at any time removed, and replaced at pleasure, as they were fastened in only with two wooden pins above, and two below, driven into holes bored in the stone. And it is here to be noted, that though, for fixing up and steadying the several articles in their places, something of fastenings to the walls were frequently necessary; yet, wherever any thing was to be affixed to them, it was never done by driving any thing into the joints, but always by drilling holes with a jumper into the solid of the stone, deep enough to answer the end required; and then, if iron plugs or bolts, they were either driven, upon a very gentle taper till they became fast, or were fixed in with lead; or, as was generally the case with the inside work, holes were bored in the solid, and oaken plugs being driven therein, and sawn off even with the surface of the stone, iron holdfasts could be very properly and effectually driven into those wooden plugs, by which means the disturbing of any part of the cement was avoided.

304. IT is to be observed, that in the present edifice I fixed the Beds in the uppermost room; and the Fire-place, which constituted the kitchen, in the room below it; whereas, in the late house, the upper room was the kitchen, and the beds (which, as I have understood, were upon common bedsteads) were placed in one of the rooms below. The former disposition was doubtless adopted, because the funnel for the smoke would be the shortest; but, as I was informed that in moist weather, the beds and bedding were generally in a very damp disagreeable state; I proposed to remedy this evil, by lengthening the funnel into the room, below the top room, by which means the copper funnel passing through the upper room, its surface being warmed by the smoke and heated air within, would communicate a genial warmth to the upper room through which it passed; and, as air when warmed has a natural tendency to ascend, whenever the copper cover was taken off, that closed the man-hole or passage from the kitchen to the bed-chamber, (and which, indeed, except at nights, would generally be the case) the warm air of the kitchen would ascend through the bed-chamber, into the lantern, and be vented there by the air-pipes made to discharge the hot air and smoke from the candles. This disposition has perfectly answered the end, as nothing can be more completely dry than the two habitable rooms. Nor are the store rooms below, subject to any moisture, to the injury of the stores, being in reality much drier than those of the former building were said to have been. Indeed this is not to be wondered at, if it be considered, that the encompassing walls are wholly of moorstone, which is a substance that does not admit of any humidity into its pores, as wood will do: and there is nothing of Parget or plaster in the whole building; for every stone fulfils its place inside and out; the piece of stone that makes the outside, being worked fair within, makes the inner surface

of the room ; and the same stones that are trod upon, as the floor in the room above, reach through and form the cieling of the room below.

305. THIS afternoon the Edystone boat came out, and brought out two chests of candles for the lights, and other stores. She also brought out sixteen cross bars for the windows, with a couple of smiths to fix them, and which were prepared as far as they could be on shore : but as by mistake they had only made half the number I wanted, the order being for sixteen *pair*, I found it necessary to send them home to forge and prepare the rest, while I proceeded, with such help as I had, to fit those we had got.—This boat was to have brought out a painter, who promised to come ; but hearing of so many being taken ill at the Edystone, he refused to come off. I therefore set one of the masons to work in painting the outside of the roof of the cupola. The copper-smith and the mason who had been taken ill yesterday, continuing unfit for work ; they, with the three joiners, and the two smiths, returned back to Plymouth this evening, in the Edystone boat.

After the boat was gone, and it became so dark, that we could not see any longer to pursue our occupations, I ordered a charcoal fire to be made in the upper store-room, in one of the iron pots we used for melting lead ; the intent of which was, that as the cross bars must exactly fit their respective places in point of length, answerable to the distances of the screws wherewith the copper sash frames were screwed to the iron pillars of the lantern, there could only be prepared on shore, holes made at one end ; leaving the other to be marked to its place. In consequence, all these holes must be bored here ; and to facilitate this operation, by annealing the blank ends of all those bars, they were made red hot all together in the charcoal fire. Most of the workmen were set round the fire, and by way of making ourselves comfortable, by screening ourselves and the fire from the wind, the windows were shut ; and, as well as I remember, the copper cover or hatch put over the man-hole of the floor of the room where the fire was : the hatch above being left open as a funnel for the heated vapour to ascend. I remember to have looked into the fire attentively, to see that the iron was made hot enough, and not over-heated : I also remember I felt my head a very little giddy : but the very next thing of which I had any sensation or idea, was finding myself upon the floor of the room below, half drowned with water. It seems, that without being further sensible of any thing to give me warning, the Effluvia of the charcoal (being from my situation more exposed thereto than the rest) so suddenly overcame all sensation, that I dropped down upon the floor ; and, had not the people hauled me down into the room below, where they did not spare for cold water to throw in my face and upon me, I certainly should have expired upon the spot.

306. THE next day, Michaelmas-day, was distinguished by the whole glazing of the lantern being completed ; and consequently now the house was in a condition to exhibit a light.—I proceeded with my Mason to bore the holes, and fit the bars ; in doing which I found we made such good dispatch, that I doubted not but we should have them all fixed before we received any more from the smith ; and this day, not having been distinguished by any other event than what is above-mentioned, it may be a proper place to mention what my intention was respecting these cross brass.—They were not indeed a part of the original design. I had conceived that the main upright standards of cast-iron (see Plates No. 12, and 15.) having their feet or claws strongly screwed down upon their Ground-sills and to their Cap-sills, which were of wrought iron, four inches broad, and almost an inch thick ; these, together with the great number of screws, fastening the copper sash frames thereto, would form so strong a frame, that no power less than what would upset the whole lantern, could make any material derangement of its figure : yet, when I afterwards considered, that all the bars, both great and small, were either perpendicular or horizontal, and consequently nothing to oppose the racking of the frame ; the violent actions of the sea, though not sufficient to break any of the parts, yet might be subject to produce such kind of twisting, agitations, and vibrations, as that by preventing the panes of glass from being at rest in the putty, might prevent their fixing therein, with that solidity which I wished. For, though underneath the putty in every pane, there were six brass pins, driven through holes drilled across the bars, by way of retaining in the panes exclusive of the putty ; yet to keep them as steady as



possible, from the causes of vibration just mentioned, I determined to place a pair of Cross Bars behind each sash frame, screwed thereto in a firm manner. In consequence, each face of the octagon having two sashes in height, the whole number of sashes was sixteen; and there were thirty-two bars: which, to make little obstruction to the light, were not only placed so as to be the least possible in the way, where the candles were commonly to be put, but were at a medium less than an inch in diameter; being  $\frac{3}{4}$  of an inch near the ends, and  $1\frac{1}{4}$  inch in the middle. These bars have in reality completely answered the end intended.—The next day, September the 30th, the glaziers had scarcely finished the puttying of all the windows of the rooms below, when the principal one was taken ill; however, he got that part of the work out of hand.

307. MONDAY October the 1st I completed the fixing of the first eight pairs of cross bars begun on Saturday; and, lest weather, or any accident, should prevent the rest from being fixed, so soon as intended, I disposed these eight pairs so as most effectually to contribute to the general purpose: for this reason I fixed them upon the N. E. S. E. S. W. and N. W. faces of the lantern, leaving the intermediate faces without any; by which means their strength became equally distributed\*.—This day also the copper funnel was finished, by the help of the plumber; and on being tried by lighting a fire, was found fully to answer. The tackle was also fixed for raising and lowering the Chandeliers; and those being hung, (see Plate No. 12.) there was now nothing to hinder our making trial by lighting the candles, while it was day-light, to see that every thing, regarding the light, operated in a proper manner. Accordingly this afternoon we put up twenty-four candles into their proper places, and continued them burning for three hours; during which time we had a very effectual trial; for it had blown a hard gale of wind at S. E. all day, which still continued; and keeping a fire at the same time in the kitchen, they both operated together without the least interference; not any degree of smoke appearing in the lantern, or any of the rooms: and by opening the vent-holes which I had caused to be made at the bottom of the lantern, for occasional use, it could be kept as cool as we pleased; whereas, in the late lighthouse, this used to be complained of, as being so hot, especially in summer, as to give much trouble by the running of the candles.

Tuesday October the 2d, the wind fresh at E. the Weston came out with two persons to be light-keepers; but, as they could not land, they were put on board the buss.—Letters brought by the Weston were delivered in the house by means of a Keg. This I got made, with an intention to convey provisions and small stores into the house, at such times as a boat might come near the rocks but not be able to land. It was made very strong, with one of the heads to take out, and fit like a plug; so as to be water-tight when driven in with a piece of canvas. This being carried by the wind and sea to the leeward of the house, could be taken up by a boat in that situation: and we found it to answer whenever we had occasion to use it. The Weston also brought out eleven more of the cross bars; which not being able to land, were left on board the buss; and, as I was desirous of getting them as soon as possible, we at low water got a rope from the house, by the keg, to the yawl; and to this fastening the bars, they were snuk with the keg, and therewith drawn into the house.

308. WEDNESDAY October the 3d, we began to fix the Conductor for lightning, (§ 174.) As the copper funnel reached through the ball, and from thence came down to the kitchen floor, above forty feet, (see Plate No. 9.) I considered this as containing so much metal, that if struck with lightning, it would thus far be a sufficient conveyance; then joining the kitchen grate to the leaden sink by a metal conveyance, the sink pipe of lead would convey it to the outside. From the sink pipe downwards, which being on the N. E. side, was consequently the least subject to the stroke of the sea; we continued the electrical communication by means of a strap of lead about  $1\frac{1}{2}$  inch broad and  $\frac{7}{8}$ th thick, fixed on the outside by being nailed to oaken plugs, drove into two jumper holes in the solid of each course; the prominent angles of the strap being chamfered off, it was bedded and brought to a smooth surface with putty. At the foot of the leaden strap, an eye-bolt of iron was driven into the rock; and to this was fixed an iron chain,

\* Was this part of the work to do again, or the like to be wanted, the cross bars would most commodiously be cast as a part of the copper sashes; and are so represented in Plates 9 and 12. But not intended to interfere with the glass panes.

long enough to reach at all times into the water; its lower end being left loose to play therein, and give way to the stroke of the waves: by this means an electrical communication was made from the top of the ball to the sea.—This day we learnt from the buss, that one of our intended light-keepers, by the rolling of the buss, had fallen, and put out his shoulder; and that the other being intimidated, refused to come into the house.

309. THURSDAY October the 4th, the wind at N. W. and moderate; the Edystone boat came out with stores and water, which were landed, as also some more of the cross bars.—The season being now advanced towards that which we had always found to grow very precarious; and every thing being now completed about the house that we could judge essentially necessary to the exhibition and maintenance of a light; I immediately agreed with three of the workmen to abide in the house, and keep the light till proper persons could be engaged with and sent off: I therefore now thought it time to take the opportunity of dispatching an express by the Edystone boat to Plymouth, to be forwarded to the Corporation of TRINITY HOUSE, giving notice for Tuesday the 16th of that month, as the day of lighting the house; which allowed twelve days for the passage of the express, and advertisements for a week previous, as ordered by the Corporation: and at the same time I dispatched the yawl, with a letter of notice to the same purport to Captain SYMONDS, Master of the Floating-Light.—The sick glazier, and the man with the dislocated shoulder on board the buss, returned with the boat to Plymouth.

Friday the 5th of October, all the cross bars were got fixed that we received yesterday. There being a great sea about the rocks, with wind at S. W. I could, by resting steadily against the wall of the lantern, perceive a sensible motion from the action of the sea. This I did not wonder at, having felt a steeple sensibly move by the ringing of bells; but I was quite surprized to find, that such heavy seas as now rolled over the adjacent rocks, without touching the building, produced a motion nearly as sensible. This, however, fully convinced me of what I had for some time been led to think, that the Edystone rocks have a very sensible degree of Elasticity.

Saturday October the 6th, the wind was at S. W. but become very moderate. The ground swell, however, that came home, frequently this day broke up as high as the windows of the kitchen, but I could not perceive that to produce the least sensible motion in the building.—This day the plumber completed every thing in his way about the balcony.—At low water the yawl brought the light-keeper who had remained on board the buss; and who having in some degree conquered his fears, made an apology for not coming before, which I thought it prudent to admit of.

Sunday October the 7th. After so severe a visitation of sickness amongst the workmen\*, all those remaining in the house, that stood their service, were employed in clearing the rooms ready to take in the winter's stores: except those who were employed in giving the outside parts the second Coat of paint, since being fixed in place.—This day the electrical communication for the lightning was completed.

310. MONDAY October the 8th in the morning, the Weston arrived at the transport buoy; being loaded with further stores for the winter; and had the remainder of the cross bars on board: these were immediately landed with the yawl; but the ground swell was too great to admit the boat to venture into the Gut; and the Edystone boat appearing in sight, which was also laden with stores, she was ordered to deliver them on board the buss. This being done, and it appearing doubtful when the Weston might be able to deliver her cargo in the Gut, she was ordered to follow the same example. As soon therefore as the tide was fallen away sufficiently, to render it practicable for the yawls to come into the Gut, a number of hands were employed to bring the stores from the buss, and land them in the house; and in the course of this tide the whole business was performed, four casks of water only excepted.—This evening the second coat of paint was finished, and the cross bars all completely fixed. A time-piece I had provided, was set up and put in motion†; and as nothing material now remained to be done,

\* There were now but few remaining hearty; of this number, however, were Mr. Jessor and myself.

† A dial for the regulating of the clock, would naturally arise from observing when the sun-beams of the south windows directly tended to the opposite ones; as this would point out the time of noon. This Time-piece, by a simple contrivance, being made to strike a single blow every half hour, would thereby warn the keepers to snuff the candles.

we determined, as the wind and weather were then favourable for unmooring the buss, to leave the house in possession of the persons appointed to keep the light, and remove on board the buss the first opportunity: and, lest time should be short on our removal, and another opportunity might not occur before the day of lighting; this evening, with the assistance of Mr. JESSOP, I gave full orders and instructions to HENRY EDWARDS and JOHN MICHELL both tinnerns; and who were the only persons that had continued steadily to act as labourers from the beginning. Those, therefore, being persons upon whom I could depend; and who had seen and assisted in the lighting of the house in the day time the 1st instant, I could have no doubt but that they would fully instruct the person entered as Light-keeper; and that my directions would be punctually observed, and the house lighted according to its destination the 16th instant; in case I could not myself be present, as I proposed to be, if wind and weather permitted.

311. TUESDAY the 9th of October, in the morning, before one o'clock, the yawl came into the Gut with the remaining casks of water, and began to remove the men, with their beds, tools, and necessaries; which being performed, Mr. JESSOP and myself, with all hands, were got on board the buss at four.—The wind was then S. E. and very moderate, the sky serene, and every thing appearing promising, we began to unmoor. We had scarcely got the eastern anchor from the ground, when clouds began to gather from the S. W. and the wind shifting into that quarter, threatened an immediate storm: however, as my maxim always was, to proceed till there was something to stop us, we went on; and fortunately, though it looked very dismal and threatening all the time, it did not blow outright; and the more dismal it looked, the more anxious we were to get out of the way of it.—In heaving up our moorings we were much surprised to find the eastern chain parted from the western; but by applying to the buoy of the western anchor it was got on board; and in heaving in the bridle, we found one of the links more than half worn through, by fretting against the rocks; it being as bright as if shorn by a file; so that in all probability the next hard gale of wind must have broke the buss adrift.—At four in the afternoon having got all our moorings on board, we hoisted sail; and it now coming on a fresh gale of wind at S. W. it drove us right into the Sound; and the tide being also in our favour, we never had so quick a passage in the Neptune Buss; for in less than three hours, we were come to an anchor in Plymouth Harbour, with a flowing tide, to the great joy and satisfaction of all concerned.—And thus, after innumerable difficulties and dangers, was a happy period put to this undertaking, without the loss of Life or Limb, to any one concerned in it; or accident, by which the work could be said to be materially retarded.

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#### CHAP. IV.

##### COMPREHENDING AN ACCOUNT OF OCCURRENCES, SUBSEQUENT TO THE BRINGING HOME THE NEPTUNE BUSS AT THE END OF THE SEASON 1759, TO THE PRESENT TIME.

312. **I**T perhaps will not be thought the least commendation to the structure of the Edystone Lighthouse, that this will not be one of the longest chapters in the whole work. In reality, very few occurrences have happened regarding it in the whole of this interval; and I trust it will be thought the very best part of the account, that in the course of thirty years, that have elapsed since the commencement of this chapter, it still remains in the same good condition, in which it then was: however, it may be proper, herein to take notice of several matters, that did not naturally fall into the course of the preceding narrative.

The very evening after we got in with the buss, it began to be very bad weather from the S. W. and which continued till Monday the 15th; so that had we not got clear of the house, and unmoored when we did, in all likelihood we must have staid there till then.



As Monday 15th proved more moderate, preparations were made, and every thing got ready to go out the next morning, in order to be present at the lighting of the house; but that morning it again began to blow at S. W. to a degree which rendered the attempt needless; and the night appointed for the lighting was stormy; which weather continued till Thursday the 18th, when preparations were again made to go out, and all stores were got on board.

313. FRIDAY October 19th. This morning appearing promising, though little wind, I went on board with Mr. JESSOP, ROGER CORNTHWAITE the mason, (whose particular activity in this building, I have had reason to notice and commend) JOHN WATT, painter and glazier, and JOHN HATHERLEY. This last I had agreed with to go out as light-keeper, upon the old establishment, instead of JOHN MICHELL, tinner, who only entered till one could be got. We went out in the Weston, being accompanied by the Edystone boat, as being the smallest and the lightest; and therefore the most easily managed in the Gut.—We had all our seamen, and also one of the yawls attending. About noon, having had but little wind, we got to the transport buoy; which we had not unmoored, intending to leave it to ride as long as it could, as it might be of service in the attendance upon the house during the succeeding winter.—As it was then about half flood; that is, about the turn of the tide toward the east, we did not think it prudent to attempt to lay either of the boats alongside the rocks, but landed in the yawl, and had the satisfaction to find all well.—HENRY EDWARDS gave account that they lighted the house, as they were directed, early on Tuesday evening the 16th, and had continued the same the two following evenings; and that they found the lights to burn very steadily, notwithstanding it blowed very hard, especially on the night of lighting.—That they had the greatest seas on Friday, Saturday, and Sunday, preceding the lighting; and that then the waves broke up so high, that had they not been thrown off by the cove course, they would have endangered the breaking the glass of the lantern: but that, notwithstanding the broken sea went in great quantities over the ball, yet no water came into the lantern by the funnel, the air-pipes, or otherwise; except that a very small leakage came in, by an upright joint in the stone-work of the lantern, which they shewed us, and which we easily remedied.—They informed us, that the seas had broke up, during almost the whole time of our absence, so high upon the house, that they were not only obliged to keep the ports of the windows shut to windward, but also to keep the joints well stuffed with oakum; for otherwise, the great pressure of the water made its way through the joints thereof, even of the uppermost chamber. That however, upon the whole, they had been both warm and dry. They further informed us, that when the seas broke up the highest, they had experienced a sensible motion, something like what we had all observed from the hole in the rock, in hard gales of wind at E.; but that being but just sensible thereof, it occasioned to them neither fear nor surprize.

This afternoon we landed a further supply of coals, water, and small stores, by means of the yawl, which completed the intended winter's provision for six months\*.—On this occasion I shall take the opportunity to observe, as intimated § 64. the wages of the light-keepers had, for many years past, been established at £. 25 per annum, finding their own provisions of eating and drinking.—I found it a matter of complaint through the country, on my first going down to Plymouth, that the light-keepers had at various times been reduced to the necessity of eating the Candles; and therefore, it seemed very much to be wished, on lighting the new house, that some scheme might be hit upon, whereby the necessity of such shocking viands might be avoided; and the remedy, with the greatest part of the observers, seemed mighty easy; "Let them have greater wages, whereby they may be enabled to buy a better stock of provisions:" or, "Let the proprietors furnish them with victuals."—On considering this matter over and over, it did not appear that either of these expedients would answer the end. £. 25 per annum seemed to many

\* Account of Stores laid into the Edystone Lighthouse, in October, 1759, by the Proprietors, as a Winter's Stock.

Coals, in $\frac{1}{4}$ hogshead casks	—	—	64 bushels.	Large candles	—	—	—	10 chests.
Water, in ditto	—	—	No. 16	Small ditto	—	—	—	1 ditto.
Lamp oil, in ditto	—	—	No. 2	Biscuit	—	—	—	3 cwt.
Salted beef	—	—	2 cwt.	Boiling pease	—	—	—	2 bushels.
— pork	—	—	1 ditto.	Oatmeal	—	—	—	2 ditto.

N. B. The above is according to Winchester measure; but the custom of dry measure at Plymouth, is denominated according to double Winchester; that is, the double of Winchester.

a very bare subsistence; but yet, being near upon 10s. a week, it was considerably more than the country price of labourer's wages, as I found it. A labourer on shore has house rent to pay, household goods to provide, and maintain, as also fire and candle. In this situation, he is at no expence, but merely meat and drink, and a few cloaths; of which he is not in need of many changes: it is plain, therefore, that it was not want of sufficient wages that caused the complaint, but want of sufficient foresight. I have given many instances, in my narrative of the progress of the building, that the high wages we were obliged to give, to induce stout labourers to face the perils of the service, did not engage them to secure themselves with a sufficient stock of provisions. Even for those short intervals they were likely occasionally to stay, their sea stock was so slender that they were repeatedly obliged to come home, after sharing their last pound of bread.—Nor did it appear that things would go better if the Proprietors were to provide sustenance for the light-keepers: for, on enquiry of the most elderly people, I understood, that formerly, as seems intimated by WINSTANLEY, the house was provided by the proprietors\*. By degrees the light-keepers got into the practice of embezzling the stores, and bartering them for strong liquors, then alleging that they grew bad, and that they were obliged to throw them into the sea; so that the eating of the candles was an early complaint; and which at that time seemed likely to be obviated by allowing them wages to victual themselves, as had ever since continued.—The most likely expedient therefore that occurred to me, was, for the proprietors to put into the house a stock of Sea Provisions sufficient to last three men for six months; which stock of provisions being the property of the proprietors, the light-keepers were to provide for themselves as they liked; the boat being to attend them as before: this stock of provisions being only lodged there, by way of securing them from starving.—Of this they might take what they had occasion for, being accountable only for what was wanting, at the season when the stock should be overhauled. In this way there could be no want, or foundation of complaint of badness of the provision; nor yet any embezzlement of the store: and provided it was laid in of the best kind, and the men only charged with what was consumed, at the wholesale price, it would come to them so much cheaper than any victuals they could provide, that it would be greatly their interest to use it; as it would enable them to live considerably cheaper in respect to sustenance, than they could possibly do on shore. In effect, none would remain unconsumed, or be any loss to the proprietors, unless some of it should turn out really bad; which would be a trifle to them, as it would seldom happen.—This being proposed to the proprietors was readily agreed to; and in this view the stock of provisions, already specified in the note to this section, was laid into the house; and was found fully to answer: and, the light-keepers being at liberty to get a joint of fresh Mutton, or piece of Beef, or a cask of Ale, whenever opportunity admitted, and they chose, all dissatisfaction about the provisions was totally prevented.—In this way matters went on for several years, till at length, by the assiduity of JOHN BOWDEN, they found themselves so frequently enabled to get fresh Provisions, and the light-keepers seldom changing, that they chiefly depended thereon; laying in themselves a small sea stock of salt provisions, to be used on emergencies; insomuch that the agent became no longer troubled in providing for them.

314. IN this visit of the lighthouse we began to give the outside faces of the upright pillars of the lantern a coat of paint, of a lead colour, the same as the Cupola, and Balcony rails, had originally been done.—These uprights being before painted white, the same as the sash frames; I had observed, on first seeing them at a distance, on our passage home on the 9th instant, they produced an displeasing effect: for these pillars instead of appearing more conspicuous, by reason of their white colour, in reality appeared not at all: for, being of the colour of the sky, not forming a sufficient contrast with the light seen through the glass, the Cupola appeared unsupported; like an Umbrella at a distance.—This circumstance I find particularly noted in my Journal; to the intent, that any one hereafter, who should in like manner think to improve the colouring of the lantern, might not fall into the same error that I had done.—We had however scarcely finished one of the faces before a storm of hail came on at N. W. which prevented our proceeding; and also cut off all communication with the vessels. Upon this we began to give

\* "But by good providence, then two boats came with provisions, and the family that was to take care of the light; and so ended "this year's work." § 20.

the inside of the cupola another coat of paint, as this could not well be repeated next season, on account of the coat of soot, that long before that time it would acquire; and perhaps prevent an adhesion with the former coat. This evening our two hands worked therein for three hours after the candles were lighted, yet so perfect was the ventilation, that though their work was principally in the roof above the candles; they did not experience the least inconvenience from smoke.—This afternoon the floating-light vessel sailed from her moorings, and coming near the rock, gave us three Cheers, which we very heartily returned.—This evening Mr. JESSOP and myself exercised all the light-keepers in their turns to trim and snuff the candles, and render them perfect therein; for, however easy and trifling such a business may seem, there are circumstances, which neglected, the effect of the light would be greatly impaired\*.—This night I took up my lodging in one of the cabin beds, and found as I had done before, that when all was shut in, and otherwise quiet, the noise of the sea breaking upon the rocks made it seem as if there was a violent storm: and being now more still than before I had used to be, from having fewer workmen; I had persuaded myself before morning, that it really was so. I was therefore surprized, on getting up, to find that the sea was more quiet than it had been the preceding evening.

Saturday October 20th. This morning being fine and dry, we finished the outside painting; and also fixed an iron hand-rail to render the passage more safe and easy from the steps cut in the rock to the foot of the ladder, see Plate No. 8: and lastly, our mason ended those rough steps.—As every thing was now done, that a further time would have induced me to do; the laying on a coat of Amber Varnish over the whole painted work, excepted; which the season would not admit of, on account of the coats of paint not being sufficiently hardened; and as the general care and superintendence of the building was to be committed to Mr. JESSOP, I had no difficulty in leaving this matter to him to be done the next spring. Having therefore read over and explained the Instructions I had received from the proprietors, for the light-keepers, fairly ingrossed; and hung the same up in a frame for their guidance; and also given every instruction I could think of, and every exhortation that I could devise, to a diligent discharge of their duty, I took my leave of the building and of the light-keepers; who were HENRY EDWARDS, HENRY CARTER, and JOHN HATHERLEY.

§15. AT noon we went on board the boats and sailed; but the wind being northerly, and not so fresh as we could have wished it, we were full twelve hours turning to windward upon our passage; so that it was Sunday morning, October 21, before we arrived at Plymouth.—During this passage the air was remarkable clear: and we were about seven or eight miles distant from the house at the first lighting this evening. The light at first appeared very strong and bright to the naked eye, much like a star of the first magnitude. Its lustre diminished as we increased our distance, till it came down to a star of about the third magnitude; after this it ceased to diminish, and on the contrary seemed to increase; this I could not but wonder at: however, at length it became a matter quite out of doubt, as to the fact, it being obvious to the whole company. We saw it in this manner till we were passed the anchoring place of the men of war in the Sound, that is, near the island of St. Nicholas, where having ceased looking at it for a small space of time, on renewing our look out, it had now totally disappeared.—Though this was a Phenomenon I did not expect, yet I had casually made an observation, some time before this was apparent, that led me to a ready explication of it. I observed, that while the light was diminishing with the distance, and yet had a sensible elevation above the horizon, a kind of luminous appearance was seen upon the surface of the sea, directly under the star-like appearance of the light; and though the surface of the water was very far from that of a plain Mirror, yet, as the top of every wave would appear to be tipped with light, in that very oblique direction, they would all become nearly united in the observer's eye. Now when the elevation of the object becomes too small to be discerned, as separated from the luminous reflection, this will become united with the direct light, so that they will appear as one; and in consequence increase, till their union becomes perfect; but in going a little further on, till the main light is intercepted by the sea; that is, till it is in reality sunk below the apparent horizon, then both the direct and reflected light will be intercepted, and vanish together.

\* This would be the case, if they should neglect to put the Chandeliers to their due height; by the interposition of the horizontal bars.



316. DURING my stay at Plymouth, which was not above a fortnight longer, (that is, till the accounts of different tradesmen were settled) I generally visited the Hoa every clear evening, being curious to observe what appearance the light made from thence. It was a fact universally agreed in, that the light in the old Lighthouse had never been discerned from thence: whatever appearance therefore it now made, was at least so much gained by the different fabric of the lantern; the candles themselves, their disposition; and number being the same as before\*. I found it required the air to be clear to see it at all, and then it appeared like a star of the fourth magnitude; but when the air was very clear, it appeared as a star of the third magnitude, and doubtless could have been seen several miles further: and, as it has been shewn, that under favourable circumstances of the Luminous reflection, the light may be seen at sea much stronger, it is probable also at a greater distance, than it can from a great elevation at land.

317. IN the times of stormy weather, that happened during this interval at Plymouth, I took several opportunities of viewing the Lighthouse with my telescope† from the Hoa, and also from the Garrison, both of which places are sufficiently elevated to see the base of the building and the whole of the rock at low water in clear weather: and though I had had many occasions of viewing the unfinished building, when buried in the waves, in a storm at S. W.; yet never having before had a view of it under this circumstance, in its finished state, I was astonished to find that the account given by Mr. WINSTANLEY did not appear to be at all exaggerated. (See § 17 and 21.)—At intervals of a minute, and sometimes two or three; I suppose when a combination happens to produce one overgrown wave‡, it would strike the rock and the building conjointly, and fly up in a white column, enwrapping it like a sheet, rising at least to double the height of the house, and totally intercepting it from the sight; and this appearance being momentary, both as to its rising and falling, one was enabled to judge of the comparative height very nearly, by the comparative spaces alternately occupied by the house, and by the column of water, in the field of the telescope.—Of this column, I made an eye-sketch at the time: and must further observe, that while I was in the Lighthouse, during the last interval of finishing, in which time we had more than one hard gale that obliged us to shut the windward ports of the uppermost rooms; I particularly noticed the manner in which the waves begun to gather, as soon as they came so near the house as to be sensible of the sloping rocks underneath them, (see § 6.) Those waves by degrees towering higher as they came nearer, formed a deep hollow sea at the foot of the building; and then falling into it, struck it with all imaginable fury. Combining this appearance with what I saw on shore, I have endeavoured to give the reader some sort of idea thereof by the figure in the Frontispiece.—All representative drawings, however, though from an accomplished pencil, must be inadequate to this subject. The exhibition being momentary, and the building for that moment entirely hid; the relation betwixt the column and the building, the principal thing desired, could not have been expressed if so represented; and thinning away the column on one side, as here done, so as to let the building appear, takes off from the magnitude of the column; and in a drawing, its appearance being permanent, it so nearly coincides with that of a *Jet d'eau*, that it will necessarily suggest this idea, better than what it is intended to represent: I must therefore refer such of my readers, as may happen to have the opportunity, to satisfy themselves, by taking a view of it from the Garrison or Hoa with a good Telescope, as soon after a storm at S. W. as the air comes tolerably clear, but not later than the day following§.

\* Viz. 24 candles at once, whereof 5 made 2lb. and they were snuffed every half hour. See Note to § 66.—I take this opportunity of mentioning, that the Lamp Oil specified in note \* to § 313, was an article never provided before. As it will keep good much longer than candles, it was intended to remedy the possibility of the want thereof. There were therefore twenty-four Lamps made to go into the Chandeliers, in place of the Candle-sockets: but as the burning of the lamps was found to produce a greater Soil upon the inside of the glasses, than candles, though no apparent smoke attended either, the lamps were never used but in cases of a necessity.

† This glass was originally fitted up for me in 1766, by Mr. JOHN DOLLOND, in his best manner at that time, with a common double convex object glass; but when I came to town the latter end of the year 1767, he fitted it with an Achromatic object glass.

‡ This is what I suppose the vulgar attribute to the TENTH WAVE.

§ This momentary Spout of the Edystone may perhaps be best compared with the momentary jet of boiling water, said to be 19 feet diameter in the orifice, and at times to rise 92 feet high, thrown from the Fountain Geisser in Iceland! described in Von THON's Letters, English Edition, page 259—261. To this account, however, I own I could have given but little credit, had it not been confirmed to me by my honoured friends Sir JOSEPH BANKS, the late Dr. SOLANDER, and Dr. LIND, who were eye-witnesses of it.

## OCCURRENCES AFTER LEAVING PLYMOUTH.

318. THE year 1759 concluded with a series of very stormy weather; and it was not till the month of January succeeding, that there was any prospect of the boat's going off. I have a letter from Mr. JESSOP, dated Plymouth 13th January, 1760; in which he mentions, that upon the 8th instant the Edystone boat went off, wind at E. and moderate, but a great swell. They got thither at four o'clock in the afternoon, but could not land. However, going to the west side of the house, they conveyed some small stores into it by means of the keg (see § 307); and by it received a letter from HENRY EDWARDS, directed to Mr. JESSOP. The purport of it was to acquaint him, that they had had such very bad weather, that the sea frequently ran over the house, so that for twelve days together they could not open the door of the lantern, or any other. —He says "the house did shake as if a man had been up in a great tree. The old men were "almost frighted out of their lives, wishing they had never seen the place, and cursing those "that first persuaded them to go there. The fear seized them in the back, but rubbing them "with oil of turpentine gave them relief." He further mentioned, that upon the 5th December at night they had a very great storm; the wind being at E. so that the ladder which was lashed below the entry-door broke loose, and was washed away. Also upon the 13th there was so violent a storm of wind, that he thought the house would overset: and at midnight the sea broke one pane of glass on the S. E. side of the lantern\*. That they had had a very melancholy time of it; having had besides, a great deal of thunder and lightning.

Mr. JESSOP further informed me, that upon the 10th the boat went out again; but the wind at east blew too fresh for her to be gotten into the Gut; that with some difficulty they landed some fresh provisions by means of the small boat; the candles, water, and beer, they could not land; but as there were several chests of candles of the original store, remaining, and a sufficient quantity of water, there could be no real want for some time.—Mr. JESSOP, however, did not give entire credit to what EDWARDS had related in regard to the house having so great a motion; as SMART and BOWDEN told him, that they could not see that the mortar in the joints had started.

319. A LETTER from Mr. JESSOP of the 13th February following, relates that upon the 8th the Edystone boat went off to the house, and landed four chests of candles, and an half hogs-head of beer. That J. BOWDEN told him he went all over the house, to see if it had received any damage by the storms, but found nothing amiss; the pane of glass mentioned by EDWARDS excepted. In short, he found all in order, the house clean, and the people well. The south pile was gone, but the north one remained firm. (See Plate No. 14.)

320. SOON after this a violent storm happened at S. W. I was informed that Admiral BOSCAWEN had mentioned to the Admiralty, that it was the greatest storm that had been known, by the oldest person on board his ship. I therefore expected a still more formidable account from Mr. JESSOP of its effects upon the Lighthouse. But no account being received in course of the post, I wrote to him the 21st of that month, desiring that, as soon as possible, enquiry might be made into the state of the house; as likewise whether it has more motion, with the wind at E. or at S. W.; and whether they were sensible of the sea's striking the cornice.—To this I received an answer, March 2d, that SMART and BOWDEN had been off the 29th of February, to land stores; that they stayed at the house two hours, and viewed it all over carefully, inside and out; but could not discover any of the mortar started, nor the joints anyways cracked: and that all the damage sustained by the last storm was, that the electrical strap, which went from the sink-pipe down to the rock, was washed away (see § 308.) The glass of the lantern was all sound; the pane excepted that was before mentioned. HENRY EDWARDS said the sea went all over the house, which caused a motion much the same as when the wind was at E. and he could perceive no

\* A number of boards cut to the size, had been provided; which might be put in from the inside in case of such accident, till a proper repair with glass could be made: as had been usual in former times.

difference when it struck the cornice, or otherwise. The light-keepers, it seems, had now pretty well got rid of their fears; as they were all well, and made no complaint.

321. EVERY thing now appearing to go on successfully and in course, I heard nothing more concerning the Lighthouse till the 8th June, 1761, of which date I received a letter in Yorkshire from Mr. WESTON. In this interval my faithful assistant Mr. JESSOP had departed this life, leaving an unblemished character behind him; and Mr. RICHARDSON had been appointed Surveyor of the Lighthouse in his stead. Mr. WESTON desired to be advised, concerning the renewal of the painting, and also respecting the restoration of the Electrical strap; both of which remained undone.—In answer, I recommended that the painting should be done by a proper painter; and not by the light-keepers, as he had suggested; and that the original colours should be preserved.—That with regard to the Conductor for the Lightning; as in our hurry in finishing, we had not had time to form a groove in the wall, wherein to bury the leaden strap, as originally intended; we contented ourselves with two fastenings at every course, as mentioned § 308; the want of which groove, had doubtless been the occasion of its being washed away from the wall. However, to render it now still more effectual, I recommended a small round bar of copper, or brass, of about half an inch diameter, to be formed; and to bury it in a groove made by the point of a pick, fixing it with small copper staples at every course, to the plugs that had been used for fixing the lead. This bar to be bedded in putty, and covered with the same, so as to make all fair and flush.

322. THE storms which the building had now sustained, without material damage, convinced us, and every one, of the stability of the Stone-Lighthouse; except those (who were not a few) that had taken the notion, that nothing but WOOD could resist the sea upon the Edystone Rocks; who said, that though they allowed it was built very strong, yet if such a storm as had destroyed WINSTANLEY'S Lighthouse, was again to happen, they doubted not but it must share the same fate.

The year 1762 was ushered in with stormy weather, and indeed produced a TEMPEST of the first magnitude, the rage of which was so great, that one of those who had been used to predict its downfall, was heard to say; *if the Edystone Lighthouse is now standing, it will stand till the DAY OF JUDGMENT*: and in reality, from this time, its existence has been so entirely laid out of men's minds; that, whatever storms have happened since, no enquiry has ever been made concerning it\*.

Mr. RICHARDSON, though a very sound hardy mason, was not a man conversant in literary descriptions. The pen was therefore, on this occasion, taken up by my very valuable and ingenious friend Dr. JOHN MUDGE; who gave me two letters upon the subject of this storm; and which, coming warm from the heart, so much exceed any thing I can compose, that I cannot do so well as to insert them.

“DEAR SIR,

*Plymouth, Friday 15th January, 1762.*

“Accept my most sincere congratulations on the safety of the Edystone; as well from the danger that has threatened it, as that I think the dreadful storm it has withstood, will for ever remove any anxiety about its being injured in future, by the united force of the wind and sea.—It blew very hard the beginning of last Monday night, but increased with incredible fury towards Tuesday morning; when about six, partly from the long southerly winds, but principally by its concurring with the spring-tides, it afforded the most horrible scene of devastation. This tide rose full two feet higher, than when the Victory was lost, and when the Fish-house† was carried away; or than was ever known in the memory of the oldest man living. The seas came in bodily over the Barbican wall, but one wave with such irresistible violence, that it swept away

\* Witness the storm in which the Halsewell Indianman was lost!—And though the public papers were full of the immense damages done by it at Plymouth, and in the Sound; (in particular a ship in the harbour that broke loose, and beat down a house, will be very well remembered) yet not a single word was said about the Edystone Lighthouse.

† The fish-house was a building ranging across the mouth of Sutton Pool, which may be called the *interior harbour* of Plymouth. Betwixt the west end of the fish-house, and the most projecting eastern end of the Jetty, or short pier, called the Barbican, an opening was left of about 65 feet wide; by which the ships entered.



the parapet, below its foundation; and in its return carried off five people then upon it, all of whom were drowned. The new Lammy Pier was swept clean away\*. Prodigious losses have been sustained by the shopkeepers on the quays; as in some of their shops near the Barbican, the water was as high as their counters; and the quays themselves are in so ruinous a condition, and so much of them carried away, that had the gale continued till the next tide, it is highly probable some of them would have been wholly swept away, and the houses with them.

"In the midst of this confusion there were no less than six large merchant ships wrecked in the very harbour, some of which were beat to pieces, but all lost; and this in the short space of 300 yards, betwixt Teatshill and Bearhead.—There were nine men of war in the Sound; several of which were constantly firing signals of distress. Some cut away one, others two, another three; and one lost all her masts and her bowsprit. Three of them only escaped with all their masts standing; one of which, to avoid immediate destruction on the south side of Mount Batton, was by the great dexterity of the pilot brought in within the Fisher's Nose, and run ashore under the Lammy: but this was when the ebb had made considerably; so that she was safely got off the next tide. But it exhibited a very uncommon appearance; as I believe it was the first time that ever a man of war was seen in that place.—In the Hamoaze the men of war were all this while firing signals of distress; and some of them ran foul of each other. The sea came over the dock gates, into the dock where the *Magnanime* was; but as there did not come in enough to float her, it did no considerable damage. The new dock was likewise filled.—I will only mention one circumstance more, to give you some idea of the extreme agitation of the sea: the Froth of it flew clean over the walls of the Garrison; and in such quantities, that in one situation a centinel was obliged to quit his post.

"In the midst of all this horror and confusion, my friend may be assured, that I was not insensible to his honour and credit; yet, in spite of the high opinion and confidence I had of his judgment and abilities, I could not but feel the utmost anxiety for the fate of the *Edystone*: and I believe poor *RICHARDSON* was not a little uneasy.—Several times in the day, I swept with my telescope from the Garrison, as near as I could imagine the line of the horizon; but it was so extremely black, fretful, and hazy, that nothing could be seen; and I was obliged to go to bed that night, with a mortifying uncertainty. But the next morning early I had great joy to see, that the Gilded Ball had triumphed over the fury of the storm; and such a one as before I had not a conception of.—I saw the whole so distinctly from the bottom to the top, that I could be very sure the lantern has suffered nothing.—It is now my most steady belief, as well as every body's here, that its inhabitants are rather more secure in a storm, under the united force of wind and water, than we are in our houses from the former only."

323. I RECEIVED the above letter in Yorkshire, where we had had very stormy weather; the account of my friend was therefore equally agreeable and astonishing: yet, notwithstanding his letter announced the general safety of the building; and that nothing very bad could have happened, even to the lantern, I could not conceive, that his expression *the lantern had suffered nothing*, could be strictly and literally true; I therefore wrote in return, desiring he would send me a circumstantial account of the damages, after the house had been visited. The following is an extract of his second letter, dated *Plymouth* the 24th January, 1762.

"The boat went off, with an intention to land, on Friday se'nnight; but there was so great a sea, and the wind being too much to the south, they desisted till the next day; when the wind being a point to north of the west, and better weather, they got near the house, landed their things, and had a long conversation with the people.

"*SMART* tells me, that the ladder was carried away†; and some small matter of putty, which was cracked by the last summer's heat, was washed off from the lantern. This was all that the

\* An erection by Government for the protection of small vessels laying against the Victualling Office, which is built upon the ground called the Lammy, extending from the Barbican southwards to Fisher's Nose; a prominent point of rock so named.

† This ladder, by which the house is ascended, from the top of the rock to the entry-door, was at first a common ladder, like that of a Lamplighter. It was so made that the sea might not have much hold of it; at the same time it was firmly lashed to Iron Eye-bolts, drove into the solid courses; yet this, by the before-mentioned instances, appearing not sufficient to resist the storms; I have since ordered it to be made, with a joint in the middle; so that when it is not in use, it may be drawn into the entry, and laid in the passage.

violence of the sea had effected; that there was not so much as a single pane of glass broke. That the lantern was secured by (that perfection of ornament) the Cornice; which, when the sea rose to the top of the house, blanched it off like a sheet. They insisted on it that the sea went bodily over the top, for, that it came in through the vents of the ball, and filled the sockets of the candlesticks\*. They were asked whether they had been under any uneasiness; they said, not in the least, as the house had not been affected by it in any other way than they had before experienced.—The storm in the evening of Monday begun at the south-east, and then they felt very sensibly a tremor from every stroke of the sea; so that while it continued there to act upon the natural cavern in the rock†, it gave them some uneasiness; which though they now believed unnecessary, yet they could not help wishing it was filled up.—Now, though I look upon this as a proof, that no storm will ever affect the house, as it is a plain smooth surface; and though a less sea has a greater influence on the rock at low water, than a mighty one has upon the house itself; yet I must say, that I concur with them in wishing it was done; and that for two reasons: One is, I should be glad to see every, the least appearance, of defect, removed; and the other, that I should hope it would give me a chance of seeing my dear friend once more, here. In earnest, I wish you'd complete the rock too, as well as the house; for so many vibratory strokes, can do it no service.

"You seem to have been greatly affected by the little I have said of the horror of this Storm; but believe me, it cannot give you even a tolerable idea of it. It has, upon a moderate computation, done above £. 80,000 worth of damage in the Harbour and Sound: and I cannot help repeating again, that I am very sure you may for ever rid yourself of an uneasy thought of the house, as to its danger from wind and sea."

"P. S. I broke open this letter to mention a whimsical circumstance, that comes in my head: One of the articles (besides sugar, some flour, &c. which they landed at the house) was a Gallipot of putty, to repair, as I said, the only derangement the house had suffered."

324. IN the year 1766, having a call to St. Ives in Cornwall, I gladly seized the opportunity of visiting my friends at Plymouth, and the Lighthouse: on this occasion, I was commissioned by the Gentlemen Proprietors of the Edystone, to inspect that building, and report my observations; which were as follows.

*Extract of the REPORT of JOHN SMEATON, Engineer; concerning the State and Condition of the Edystone Lighthouse, from a View thereof, taken the 10th August, 1766.*

HAVING carefully inspected this Edifice, I had the satisfaction to find, that no one part had in the least degree given way to the rage and violence of the sea; but that the mass of building was sound and firm as at first: nevertheless there appeared some matters, that I thought worthy of regard: which are in order as follows.

The cement every where below high-water mark; and from three to six feet above it, was perfectly entire, as left by the Trowel, and seems changed to the colour and consistence of Iron-Stone.—From thence to ten or twelve feet above high-water mark, the cement appears here and there to be somewhat impoverished in the joints, or fretted; and I observed that this was more so on the East side than on the West: above the parts last described, the cement appears perfectly flush in the joints, quite to the top, as left by the trowel, being no ways altered in colour or consistence.

From the above appearances it seems to me, that those parts of the building that are generally wetted every tide, are in the highest degree of preservation; those that are wetted seldom, are nearly the same; but those that are frequently wetted, but not always, have suffered most by the alternate action of the sun, wind, and of the sea salts: was this to go on several years longer, nothing is likely to happen that would materially affect the strength of the building; yet in a structure of so much consequence, and which can so easily be restored to its primitive state, it would seem negligence to let it remain unrepaired.

The electrical conductor is complete down to the rock, as to use; but of the chain that hangs

\* This might possibly happen by the falling of a detached mass of water into the Vents made for the clearance of the smoke.

† See Plates No. 6, 8, and 14.

from the top of the rock into the water, about half of the lower part is gone; by its wearing away with rust, and beating against the rocks. I have ordered a new one to be made of stronger iron. From the rock, for about twelve or fourteen feet upwards, the communication is by Brass bars let into the house side, in a little groove or gutter, in which they lie buried in putty\*; and which seem to stand very well; the rest of the outside communication is by the original strap of lead, that I fixed there†; but as about half a yard of the lower part of the lead is getting loose, I ordered Mr. RICHARDSON to let in another length of brass bar, like the former; and so on, as the lead fails.

The balcony rails have as yet suffered very little, considering their exposure: but as flakes of rust seem gathering under the paint, I ordered it to be knocked off with proper tools before a fresh coat of paint is laid on.

The whole of the lantern is in remarkable preservation, scarcely a speck of rust appearing on the outside, and only a few specks within; which are chiefly upon the ribs, and knee pieces under the cupola; those specks I ordered to be first scraped off, and then fresh paint laid on.

I was much surprised to see the gilding of the ball, which, notwithstanding its exposure, and the smoke of the whole house going through it, appears as bright as it did the first day it was screwed on. The lantern has always continued remarkably water-tight, not the least wet ever beating through any part of it, except in high storms; and what gets in between the glass and the copper frames, by the drying and cracking of the putty; but this so seldom and so little, as seems not worth regard.

The loops and crooks of the doors and window ports have suffered most of all by the rust; and particularly those parts of the iron that are on the inside; but as all these things are renewable at pleasure, they are not to be esteemed of any consequence; especially as they seem likely to last many years.

The Cavern in the rock on the east side, seems exactly in the same state I left it. In hard gales of wind at east, it is said to cause a wonderful noise; and a sensible tremor in the building: but though it makes more noise, the light-keepers say it does not affect the building, with so sensible a vibration, as the heavy seas from the S. W.; and yet even those are not much more than to be readily perceivable in the greatest storms‡. Whether this cavity in the rock may ever prove of any detriment to the building is not to be determined with certainty: all that can be said, is, that hitherto it does not seem to have been of any hurt thereto. I could undertake to fill it up and make it solid, at the expence of about £.250, besides my own attendance, if it was thought worth the charge.

Besides the pleasure of finding all the main Stamina perfectly sound and firm, and every thing else likely to endure for many years to come; I had the satisfaction of finding every thing in the inside so perfectly neat and clean, that it seemed as if it had not been a twelvemonth in use.

Austhorpe, 30th August,  
1766.

J. SMEATON.

325. FROM this time nothing further occurred till the year 1777, when having a second call into Cornwall, I again took the opportunity of visiting Plymouth: and though I had no commission to inspect, &c. yet my own curiosity prompted me to visit the Lighthouse: and I had the great satisfaction to find that Mr. RICHARDSON had so well attended to my last instructions; and its condition was so nearly the same as in the year 1766, that very nearly the same report would have served; every thing was neat and clean, and in good condition; no other change or repair having happened, except that of repeated paintings of the metalline parts, which appeared still in high preservation. This visit to the Lighthouse was in the month of September.

\* See § 308.

† From the report of SMART and BOWDEN I concluded the whole of this strap was washed away, (see § 320): hence we may see how very liable men are to be mistaken in matters to which they are not perfectly competent; even where they have no interest in deceiving or being deceived.

‡ Hence we may see demonstrably, how much the same things are liable to be magnified, when people are under fears and apprehensions; and perhaps at the same time inclined to magnify; HENRY EDWARDS says in his letter, § 318. "the house did shake as if a man had been up in a great tree." HENRY EDWARDS had at this time quitted the service; but the effects of the sea upon the house must be presumed to continue the same.



326. IN the year 1787, having a call to Plymouth Dock, I again took this opportunity of gratifying my curiosity by inspecting the Lighthouse; and also spent some days in getting the necessary Trigonometrical operations for determining the real distance of the Edystone from the Ramhead, from Plymouth Sound, and from Plymouth Harbour: and though I did not find them materially different from what I had put them down in the former part of this work, § 4. (which was then printed) as deduced from bearings, compared with the maps of the adjacent coasts, from whence Plate No. 2 was compiled: yet, observing some contrariety in the results, I was desirous of settling this matter from more authentic materials, than my opportunities would give me leave to collect while the Lighthouse was building and finishing. The particular result of these operations I shall give with the technical description of Plate No. 18.

327. MY visit to the house was the 3d August, 1787; and I then had the satisfaction to find both stone and iron so very nearly in the same state, as I had found and reported it twenty-one years ago, in the year 1766, that I was agreeably surprized: the only thing in which I could perceive a change, was, that the cement in the upper works was in most places sensibly corroded. I could not, however, estimate the quantity in general, at more than one-sixth of an inch, that the present mortar surface wanted of flush with the face of the Granite. Had the whole building been of Portland stone, and supposed, in such a situation, to have lost of its whole substance an equal quantity: had the mortar wasted equally, the whole would have been a fair surface.—Of all the lower parts, including the whole work of the year 1757, being the first year's building, and which is generally wet every tide, there did not appear on this last visit to be the diminution of a grain of sand, but they appeared exactly as the same parts are reported to be in 1766: that is, the mortar having the appearance of Iron Stone; the Limpet shells, and sea weeds, fixing indiscriminately upon the mortar and the stone. But above that, as the eastward joints are more sensibly affected, and somewhat irregularly; to about the height of the entry-door, and after that are pretty uniformly in the degree I have already related; I am much inclined to suppose, that in raging storms the sand is raised from the bottom, and mixed with the water, and being driven violently against the building, may be capable of grinding, and making an impression upon what is compounded with calcareous matter, (however hard it may be, and in reality is) that it cannot make upon the Moorstone: which nothing seems to affect but a considerable degree of fire.—This is, however, not the case on the S. W. side; though that sustains the first stroke of the sea: for the sea-weed fixing itself the highest on that side, becomes a defence to the joints in this part.

Since my visit in 1777, the very careful and diligent Mr. RICHARDSON departed this life.—Mr. RICHARDSON, during life, remained sensible what patience and assiduity were necessary, during the course of the work of the first and second year, not only to repair the pointing when injured by a rough tide; but to look to it again and again till it had stood a rough tide: On the present visit I was disgusted with seeing the joints, in several places of the second year's work, made up with glazier's putty, which was an expedient of the light-keepers, when the masons mortar did not happen to stay on, after their departure. This, though it would often stay in the joint when the mortar would not; yet, being of unctuous matter, it hinders the union of the proper cement with the stone, and becomes a means of preventing those joints from being made complete and flush in the way they were at first. It also disgraces the work with party-coloured mortar.

328. AS the Iron Work still endures with very little apparent injury, having had a coat of paint every two years; and this standing remarkably well, in spite of its exposure to the sea-salts, many persons have been curious to know the manner in which this part of the work was originally performed.—I then conceived the exposure of the rails in particular to be such, as to require every advantage that could be put in practice: and after considering the matter, I determined upon the following method; which, as it appears to have succeeded, I dare say my reader will like to know.—I had observed, that when iron once gets rust, so far as to form a Scale, whatever coat of paint or varnish is put over this, the rust will go on progressively under the paint, unless it is eradicated by being knocked off, and scraped.—The most effectual way therefore seemed, to endeavour to apply the protective coat, before any rust could be formed.

After the rails were made in eight compartments, and screwed together, I ordered that they should not come out of the smith's shop, till they were to undergo the following operation.—A fire was made, though not very strong, yet extensive enough to heat the whole of a compartment together, tolerably equal, till the iron came to about, or rather above, a blue heat; this part was then removed and another applied; and while it was heating, a couple of men with brushes, struck over the surface of the former with raw Linseed oil. This at first would smoke, and nimbly run into every joint, crevice, and flaw in the iron; and the operation was continued, till every part had at least been gone twice over; and the oil would begin to lie fluid on its surface. It was then set by to dry; and the rest followed in the same manner. The next day, if properly done, the surface of the whole would appear to be covered with a thin coat of varnish. The doing this to purpose is what the main matter consists in\*. As soon as it was well dried a couple of coats of common white lead and oil paint were given: after these were dry, the Rails came down by sea to Plymouth, and from thence were carried out, and set up upon the Light-house; and there, as I have related, they were finished with a couple of coats more, in place.—Doubtless by these carriages, the coats laid on at London, were a good deal scratched, and in point of appearance spoilt, but in point of utility were little the worse: because, it was only the prominent parts that could be scratched and rubbed; and therefore the brush could not fail to make these good, in preference; and, as they would get two coats in place, they must be considered as sufficiently covered; whereas, all the intricate, retreating parts, would have the whole five coats remaining entire upon them.

329. ON this visit I found the lustre of the ball was considerably diminished. But as the Gilding was perhaps the only part of the whole work that was merely Ornamental; and as much cost did not attend it, in its first application; as it has lasted thirty years in good splendor, and is not yet wholly effaced; it may be alledged, that it has sufficiently answered every purpose there was in view at the time: and whenever it shall appear to be necessary to renew it, I doubt not but ways and means will be found.

In examining the skirt of the leaden cap, turned under the drip of the Corona, that I had carefully battled to the stone (see § 302): on the south-west side I found it to hang down more than an inch. On enquiring whether the great storms had any sensible effect upon it, I was told by the light-keepers, that in the storm of January 1786, (remarkable for the loss of the Halsewell Indianman) the lead was considerably raised up, by the action of the sea, on the south and S.W. sides; but that they had beat it down again, as well as they could.—Of this I apprized my respected friend HENRY TOLCHER, Esq. the Agent; and that it would be necessary to send off an intelligent workman, to bat the lead carefully to the stone under the drip, as at first; and that where it was become too broad, it might be cut narrower.—I conceived that the feet, and other bodies that are continually making impressions, and striking small blows upon the balcony floor, had in time stretched out the lead: and its own weight would also contribute to increase the effect.

330. BEFORE I conclude this narrative I wish to meet an enquiry, that has very often been made with a degree of surprize: How is it possible to find men that will seclude themselves from the world, and the comforts of life, for so small a consideration, as a salary of £. 25 a-year; when I found myself under the necessity of giving such high wages to the workmen employed in erecting it? intimating, that it might rather be considered as the alternative for condemned Felons, than an appointment for which people would make interest.—The case is, the Lighthouse is supplied with light-keepers from a different sort of men to those, the question supposes†. A man while he is in his youth and strength generally enters into the engagements of a family.

\* A person repeating this process, if he finds the oil not to be dry like varnish the next day, may conclude; either, that he has continued the striking with oil too long, till the iron was too cold; or, that he had not heated it sufficiently.

† I was applied to in the course of the last season, by a philosopher kind of man, to be one of the light-keepers; observing, that being a man of study and retirement he could very well bear the confinement, that must attend it: I asked him if he knew the salary: he replied, not; but doubted not it must be something very handsome. When I told him it was £. 25 a year, he replied, he had quite mistaken the business; he did not mean to sell his liberty for so low a price; he could not have supposed it less than three times as much.

and an industrious man so situated, no consideration would hire to part with his liberty. But when he comes to be above the age of Sixty, and has still his bread to earn by his own labour; an easy birth, in which he can get as much as he could do formerly, becomes a very eligible thing; especially to those who are not otherwise encumbered. To elderly Seamen, it may be considered as an Asylum something like equivalent to Greenwich Hospital.—Formerly there were seldom less than half a dozen applicants upon the agent's list, ready to supply a vacancy; and as no one was under the necessity of staying longer, than till, after giving notice of his intention to quit the service, a fresh man was sent out to fill his place, those vacancies happened frequently. At present they happen so rarely, that very few think it worth while to apply. JOHN IRELAND, who is the senior of the present set, entered with me in the year 1756 as a seaman. When the building was finished, JOHN, being stout, hearty, and willing to work, shipped himself on board a trading vessel, and continued for some time to use the sea. However, a few years more of hardship, and advance in life, occasioned him to change his mind; and, I believe, on EDWARDS quitting, he entered. I found him there in the year 1766; in the year 1777; and on my last visit in 1787.—The second man I also found there in my visit of 1777; and the present third man, who was at this time taking his month on shore, (see § 63) I was told had been a light-keeper four years; and had succeeded one who had been there fourteen years; and who neither being very old nor very infirm, probably would have been in the Lighthouse at this time, had his death not been premature, which occasioned the vacancy\*.—These facts, more strongly than any arguments, prove that this Lighthouse as an Habitation (singularly situated, exposed, and circumstanced as it is; and where water was never known to freeze) is not only remarkably healthy; but really comfortable to a degree, that renders it eligible to a certain class of men; who do not consider their abode there as any infringement upon their liberty, because they well know it is in their own power to put a period to it, whenever they chuse.

\* As the death of this man exhibits a remarkable trait of human nature, on this account I insert it. In the fourteen years that he had been here, he was grown so attached to the place, that for the two summers preceding he had given up his turn on shore to his companions, and declared his intentions of doing the same the third; but was over persuaded to go on shore, and take his month's turn. He had always in this service proved himself a decent, sober, well-behaved man: but he had no sooner got on shore, than he went to an Alehouse, and got intoxicated. This he continued the whole of his stay; which being noticed, he was carried in this intoxicated state, on board the Edystone boat, and delivered in the Lighthouse, where he was expected to grow sober; but after lingering two or three days, he could by no means be recovered. The reflections arising, I leave to my reader.

331. THE following words, letters, and figures, were sunk into the Moorstone with the point of a pick.

Upon the first stone of the foundation - - - - - 1757.  
Over the Entry-door - - - - - 1758.

Round the upper Store-room, upon the course under the ceiling,

EXCEPT THE LORD BUILD THE HOUSE  
THEY LABOUR IN VAIN THAT BUILD IT.

PSALM CXXVII.

Over the south window, on the outside of the dwelling room, or kitchen 1759.

Upon the outward faces of the octagon basement of the lantern,



♦ NE ♦ door ♦ SE ♦ S ♦ SW ♦ W ♦ NW.

Upon the last stone set, being that over the door of the lantern on the east side,

24<sup>TH</sup> AUG<sup>T</sup> 1759.

LAUS DEO.



# GENERAL ABSTRACT OF THE PROGRESS OF THE WORK OF THE EDYSTONE LIGHTHOUSE.

DATE.		Time upon the Rock.		Number of Pieces of Stone
		Hours	Days and Hours	
1756.	August 5. November 22.	Began to cut the Rock for receiving the foundation. The principal parts thereof being completed; the Neptune Buss quitted the moorings; after which she was driven out to sea by a storm, to the westward of the Land's End. Returned to Plymouth the 26th. In this year the time out upon the work was 110 days = 15 weeks 5 days: and upon the Rock — — — — —		
		348½	14 12½	
1757.	June 12. August 11. October 1.	Landed the first stone. Completed the first six foundation courses — — — — — Finished three courses of the solid shaft, consisting of 53 principal pieces each; and one stone let into the Rock, to make good a chasm therein over the Cavern — — — — — In this year the time out upon the work was 113 days = 16 weeks 1 day: and upon the Rock — — — — —		
		342½	14 6½	123
		288½	12 —½	160
		631	26 6½	283
1758.	July 2. August 8. September 24. October 7.	Landed the first principal piece of course X, being the first stone this season. Completed the Entire Solid up to the Entry-door, inclusive of course XIV. Finished the solid to the Store Room floor, inclusive of course XXIV. — The last stone of this year's work was fixed; having completed the walls of the Store Room, consisting of 78 principal pieces; and set 14 pieces of the first vaulted Floor — — — — — After which, on the 8th, the Neptune Buss parted her cable in a storm, and was driven into Torbay; from whence she got into Dartmouth Harbour: and afterwards returned to Plymouth. In this year the time out upon the work was 99 days = 14 weeks 1 day: and upon the Rock — — — — —		
		237	9 21	265
		416½	17 8½	383
		127½	5 7½	92
		781	32 13	740
1759.	July 5. August 16. — 26. October 9. 16.	Landed and began the work of this season. Completed the Balcony Floor, and therewith the Main Column — The Basement of the Lantern, the stone Stairs in the Well-hole, and all the stone work completed — — — — — The Lantern, and the whole of the Building, with its equipments, completed: the workmen left the house, with three light-keepers and proper stores therein; with orders to light the house upon the 16th. Unmoored the Neptune Buss, and carried her into Plymouth Harbour — — — — — This evening, according to the appointment of the Corporation of TOWNITY HOUSE, the light upon the Edystone was rekindled. In this year the time out upon the work was 99 days = 14 weeks 1 day: and upon the Rock — — — — — Totals of the four years; out upon the work 421 days = 60 weeks 1 day: upon the Rock — — — — —		
		502	20 22	598
		119½	4 23½	72
		222	12 4	
		913½	38 1½	470
		2,674	111 10	1,493

Besides the larger Pieces of stone above specified, the mass of Masonry inclosed the following smaller parts; which the regularity of the construction enables to particularize.

- 75 Large cubic Joggles and center-plug stones.
- 162 Cubic Joggles of 6 inches, used in the Well-hole courses.
- 399 Flat Joggles in the courses of the rooms and lantern.
- 399 Joint stones in Do. — — — — —
- 1,800 Oaken Trenails of 1½ inch diameter used in the solid.
- 4,570 Pairs of oak wedges for steadying the stones of the solid.
- 8 Large circular chains, two used at each vaulted floor.
- 221 Strong iron cramps, used in the walls of the rooms and lantern.
- 5 Do. — — — in the foundation, in consequence of accidents.

N. B. The whole time intercepted betwixt the first stroke upon the Rock, and leaving the Lighthouse complete, was 3 years, 9 weeks, 3 days.

And the whole time from the Fire taking place, in December 1755, to the rekindling of the light, October 1759, was 3 years, 10 months, 16 days.

The whole time of working upon the Rock (being 111 days, 10 hours) amounts scarcely to SIXTEEN WEEKS.

## APPENDIX.

*Containing an Account of the Establishment of the present Lights upon the SPURN POINT,  
By Direction of the Honourable Corporation of TRINITY HOUSE, Deptford Strond,  
LONDON.*

332. IN the year 1676 a patent was granted by King CHARLES II. to JUSTINIAN ANGELL, of London, Merchant, enabling him to continue, renew, and maintain certain lights that he had erected upon the Spurn Point. Which lights were erected at the request of the masters of ships using the northern Trade; who, in their petition to his Majesty, represented that a very broad long Sand, about six or seven months before, had been discovered to have been thrown up near the mouth of the river Humber, upon which they had had great losses; and by means whereof they sailed in great danger in the night; and that having considered, that lights erected upon the Spurn Point would in future prevent such danger, this had induced them to apply to Mr. ANGELL, as being the proprietor of the only piece of ground, that was adapted to the purpose; and who, at their request, had erected two lights thereon; which the petitioners found to be not only of great benefit, but an absolute safety to all navigators on that coast.

In process of time, the Broad Long Sand, complained of in the petition, became itself a dry land at high water; and which continued to increase considerably: for, antecedent to the year 1766, the lights thus established by Mr. ANGELL were, by the gradual extension of the real point of the Spurn, become now at so very great a distance therefrom, that the masters of ships loudly complained, that the said lights were so far from being of that benefit they originally had been, that they were become detrimental to them; by inducing them to suppose themselves more near to the point than they in reality were. In fact, that they were deceived thereby, and in consequence many very great losses had lately happened\*.—Wherefore an application was made to parliament in the year 1766, promoted by the Corporations of the TRINITY HOUSES at Deptford Strond, and Hull, for removing the said lights; and an act passed in consequence, *Anno sexto GEORGII III. Regis, Cap. 31.* “*An act for taking down and removing certain Lighthouses now standing near the Spurn Point, at the mouth of the Humber, and for erecting other fit and convenient Lighthouses instead thereof;*” whose preamble sets forth, that JOHN ANGELL, of Stockwell, in the county of Surry, Esq. was owner of three-fourth parts of the said Lighthouses, duties, and profits; and that LEONARD THOMPSON, of Sheriff Hutton in the county of York, Esq. was proprietor of the other fourth share thereof. That Mr. ANGELL having been applied to by the said Corporations, and also by the said Mr. THOMPSON, to change the situation of the said Lighthouses, so as to answer the ends and purposes for which they were originally designed; and this application having been ineffectual, it is thereby enacted; That the said LEONARD THOMPSON should be intituled, as soon after the first day of June 1766 as conveniently could be, to erect two new and sufficient Lighthouses, with suitable offices and conveniences, at or near the said Spurn

\* The spot of ground called the Spurn Point, seems to have undergone great changes; for in CAMDEN's time, about a century before the petition for erection of lights, there seems to have been no more than a pretty sharp Head of land, that did not extend far from Kilmsey, and was then called Spurn Head. His words are “*Inde in ipsâ promontorii Lingulâ quâ maximè in Conum contrahitur & SPURN HEAD dicitur KELLSEY visitur viculus.*” CAMDEN's Britan. svo. Edit. 1590, p. 580. It seems therefore gradually to have been drawn out to a greater length, and to a sharper point of land: taking the name of Spurn Point, upon which the Lighthouse was erected, and to which the broad long sand afterwards attached itself, and became dry land in the shape of a Spoon, which form it still retains.—There is also an obscure tradition current, that upon a flat of ground just within the Point that now but just dries at low spring-tides, there stood a considerable town called RAVENSPURN: and some pretend they have seen traces of its foundations.

Point; according to such plan and estimate, as the Master, Wardens, and Assistants of the said Corporation of TRINITY HOUSE, Deptford Strond, should by writing under their common seal specify, appoint, and approve of: and in the mean time, and until the said new Lighthouses should be completed, to erect two Temporary Lights, as near as may be to the respective places where the new Lighthouses shall be appointed to be built: and, as occasion might require, to enlarge, contract, alter, or remove the same, with the consent, and by the direction, of the said Corporation so signified. The said Lighthouses to be subject to the visitation of the Trinity Houses of Deptford Strond and of Hull.

333. MATTERS being in this state, the Corporation of TRINITY HOUSE, Deptford Strond, did me the honour to request my attendance to meet a Committee of their body, appointed to proceed to the Spurn Point to take a survey, and give directions in respect to the situation and erection of two new Lighthouses; and of temporary lights, pursuant to the act of parliament lately passed for that purpose. Accordingly I met JOHN BARKER, Esq. and THOMAS BENNET, Esq. the Committee appointed, at Hull, the 22d June 1766; and the next day attended them, and a deputation of the Trinity House of Hull, to the Spurn Point by water: when the gentlemen of the said Committee, after examining the ground, and hearing every matter of information that was offered to them, fixed the places for the two Lighthouses; and also for the temporary lights, as near the extremity of the point of the Spurn, as they could with the appearance of safety be built; and which situation was at the distance of more than a mile from the old Lighthouse: all which they proposed to lay before their Board for their concurrence.

They particularly enquired from me, considering the ground where the proposed Lighthouses were to stand, being a sand thrown up by the sea, in the course of less than a century, whether I could undertake to erect Lighthouses of Brick thereupon: and particularly, if one of them was to be ordered of 90 feet high to the center of the light?—To this I answered; That though the ground whereon they proposed to erect the lights was new Ground, in comparison of that whereon the present Lighthouse stood; yet, as it appeared to be of the same quality, whereon that had already stood 90 years, without apparent crack or settlement; I did not doubt of making a foundation, at least as much more firm than that of the old one, as the new building should be more lofty; and that it would stand, as long as the ground remained, that it stood upon: and in regard to this, it was the unanimous opinion of the whole company, that as the Spurn Point was a piece of ground that was rapidly increasing, there would be no danger of the ground being washed away. Therefore the judgment would be, to place the new lights as near the present point as possible, that there might be the greater course of years before the land, that doubtless would be added, should cause the necessity of a second removal.

In respect to the temporary lights; having then examined the low light machine, called a Swape\*: though that was scarcely capable of hoisting the light above 25 feet above ordinary high water, yet, I doubted not but to produce a machine upon the same principle, so much more complete, that it should hoist the light 50 or even 60 feet high if required: and which I recommended to their consideration.

334. IN the autumn following I received from CHARLES WILDBORE, Esq. Secretary of the Trinity Board, the Corporations directions concerning the Spurn Lights, as follow:

*The Situation, Heights, Dimensions, &c. of the new Lighthouses and Temporary Lights to be erected at the SPURN POINT; as agreed on at a General Court of the Corporation of TRINITY HOUSE, held 12th July, 1766; viz.*

\* The lights then subsisting though in the original patents and the present act they are called Lighthouses, yet it does not appear that the low light was ever exhibited otherwise than upon a Swape (a north country term for a Lever, when fixed upon a centre, and acted upon by the hand) and which works in a way, very similar to that by which water is drawn by a bucket out of such wells as are not deep, in the garden grounds about London, and many other places: and which machine, as the coast wore away, being moveable, was now placed upon the beach near high-water mark.

The Great Lighthouse was a strong octagon building of brick; and its light, also hoisted on a Swape, was a naked coal fire, which, being unprotected from the wind, was subject to burn with very different and unequal lustre: and it is related by the master of this Lighthouse, that in the storm of 1703 (when that of the Edystone was beat down) he "verily believed his tower (20 yards high) would have been blown down; and the tempest made the fire in it burn so vehemently, that it melted down the iron bars on which it was laid, like Lead: so that they were forced, when the fire was by this means almost extinguished, to put in new bars, and kindle the fire afresh." *The Storm*, p. 227.



# ESTABLISHMENT OF THE PRESENT LIGHTS UPON THE SPURN POINT. 187

The lights to be in a N. W. and S. E. direction; and to be 300 yards asunder.

The great Lighthouse to be placed on the Spurn Point, at a distance from high-water mark (at common spring-tides) of 90 yards, in a N. E. and S. W. line; and 150 yards in a N. W. line, within the Spurn.

The small Lighthouse to be 116 yards distant from high-water mark in a S. E. line, without the Spurn.

N. B. The breadth of the land from sea to sea, in a N. W. and S. E. line, is 566 yards; and the soil is the same as in other places, where the sand grows up from the sea; viz. gravel mixed with sand, and a moderate quantity of shingle.

The Lighthouses to be built with Brick: the large one to be 90 feet high, from the mean surface of the ground to the center of the light.—The small one to be 50 feet high; that is, 40 feet lower than the other: both with inclosed Lanterns for Fire Lights.

The two Temporary Lights to be placed in the same direction as before mentioned; 250 yards asunder; and to be 23 yards to the S. W. of the ground marked out for the Lighthouses.

The Great Temporary Light to be 50 feet high)  
The small one - - - - 35 feet high} both with Swapes for coal fires.

It will be necessary to have a platform from one light to the other, for the men to walk on in the nights; about three feet wide, with a rail on each side\*.

335. THE beginning of the ensuing year I produced to the Board a set of Designs for the erection of the two Lighthouses; and of two temporary Light Machines, conformable to the foregoing directions; and estimates for the same: which being considered by the Board, were approved, and passed the common seal of the Corporation, the 21st February 1767. Those being afterwards delivered to LEONARD THOMPSON, Esq. he proceeded to the execution thereof; and in the course of that season, built two Temporary Light Machines, according to the designs†; as also dwelling-houses, and conveniences for the residence of the light-keepers: which being lighted, according to due notice given, were found to answer the end so completely, in point of situation, height, and construction, that the trade seemed entirely satisfied therewith.

The temporary lights being thus established, and Mr. THOMPSON finding difficulties in getting a contract for the erection of the Lighthouses, two years elapsed without further progress; after which, in virtue of a Proviso in the said act, the Corporation of TRINITY HOUSE, Deptford Strond, became entitled to execute the further purposes thereof; and to this being also requested by Mr. THOMPSON, advertisements for contractors were put forth; and at a meeting of the Corporation, of the 7th April, 1770, Mr. WILLIAM TAYLOR, of York, appearing to be the lowest proposer, was declared the Contractor; and afterwards articles of agreement were entered into in consequence.

336. THE 6th of May 1771, I had the honour to be appointed, by writing under the Common Seal of this Corporation, to be their Surveyor; for them, and in their behalf to superintend, inspect, order, and direct the execution of the works contracted to be done by the said WILLIAM TAYLOR, in such manner as I should see most conducive to answer the end proposed. In consequence of this appointment I visited the Spurn Point the following month, when Mr. TAYLOR had got together materials; but not having begun, it appeared to me, that since the year 1766, the sea had so far encroached upon the eastern coast of the Spurn Point, that the very place fixed for the Low Lighthouse, at 116 yards within high-water mark, according to the line of direction, was now in the very high-water mark itself. (See Plate 20, Fig. 2.) I therefore suggested to the Board, that it would be proper to shift the place of the Low Lighthouse; as they had marked it out, so as to be 80 yards more inland; or to N. W.: which alteration being approved, Mr. TAYLOR began the foundation accordingly.—And furthermore, as it was possible the sea might in process of time make an attack upon this building, I directed Mr. TAYLOR to drive as many piles under the outward circle of its base, as should bring them close together, and

\* The above resolutions, as well as what precedes, will be fully explained by the literary references to Plates Nos. 19, and 20.

† Plate No. 24, Fig. 2d, shows the elevation of the great temporary Light Machine. In its original state, its base was sunk into the ground, to keep it steady; but it is here shewn set upon walls, as it now serves for the Low Light.

to drive them as deep as they could be got into this sand; which on trial was found to be about nine feet\*.

The 23d July the piling of this foundation was finished, and the brick work begun; but the Contractor had scarcely got the work up to the level of the ground, before he was interrupted by an attack from the agents of Mr. ANGELL; which shewed the necessity of an amendment in the act: the obtaining of which stopped the works for above a twelvemonth. The latter end, however, of the year 1772, the foundation of the High Light was begun: and, by the approbation of the Board, it was placed 60 yards more towards the N. W. than originally intended, to make up in part for the 80 yards we had given up upon the S. E. side. I did not think it prudent to take the whole 80 yards; because, though the N. W. coast had apparently gained, it did not appear certain, how much or how long it might continue so to do. The distance of the houses, therefore, as now settled, was 280 yards.

The beginning of February 1773, the foundation for the High Light was completed: and in December following, the Low Lighthouse was covered in; and the High Light got 40 feet high.

337. TILL my visit in June 1771, I never had gone to the Spurn Point by land; in consequence I had had no opportunity of remarking that the sea was encroaching upon the whole Coast, quite from Bridlington to the high grounds at Kilnsey. I then saw the coast was in a state of wear, but it was not till my visits in the year 1774, that there had been a sufficient interval, to ascertain the rate, at which the sea was annually washing away the high clay cliffs of Kilnsey: which, as near as I could then estimate it, was at the rate of 10 yards a year.—As the Low Light was then erected, the information naturally drawn from this observation came too late; for though I perceived that, as had been suggested in the year 1766, the Point of the Spurn was increasing, yet it was chiefly in length. I now found that the high-water mark was not in reality more than 40 yards from the center of the Low Light; I therefore concluded it could not be many years before an attack must be made upon the Low Lighthouse; but, as I had for some time considered the Spurn Point as an appendage to the high cliffs of Kilnsey; and formed from the waste of the lands to the North; therefore, at whatever rate the sea encroached upon these cliffs, by taking off parallel Screeds, this whole appendage of the Spurn must remove at an equal rate westward, upon the average. It, however, might alter some years more, others less, according to the casual influence of storms.

338. ACCORDINGLY, a great storm happening in January 1776, took away so much of the S. E. coast in general, that it not only took away entirely the site of the old Lighthouse; but first laid bare the circular Court wall of the Low Light; and then taking away the sand below its foundation, beat down one half of its circumference in a single tide; and ceased not till it had laid bare the close piling under the circumference of the main building, driven for its protection. (§ 336.)

On visiting Spurn Point on this occasion, I ordered down a quantity of Hazlecliff stone† to be deposited, so as to form a sloping Bank or Bulwark at the foot of the building, to break off the fury of the sea, till the season should come on when something more effectual might be done; and left the further progress and application of the same means to Mr. TAYLOR, who had constantly resided upon the place.

339. IN reflecting upon the observations I had made, and have already stated; I plainly perceived, that to defend this building against the future attacks of the sea, nothing less could avail than what would defend it as an Island at low water: this, though not impossible, would be so expensive, as greatly to exceed that of rebuilding it, as often as it should be beat down. I

\* The design of the Lower Lighthouse, was perfectly similar to that of the Great Light, in respect to the Lantern and Pipe Room; but the Body of the Light itself being less, the diameter of the lantern, and all below, to its base, were proportionably less; so that being 40 feet lower than the other was intended, it consisted of fewer rooms in height; viz. a Coal Vault, in the base story, a Dwelling Room, Pipe Room, and Lantern.

† A kind of hard chalk-stone, got near the Humber side, above Hull, and much used in this country for all kinds of rough works, and defences against the waters.

therefore advised the Board not to enter into any formidable Expenditure, but to give the injured parts a repair or re-establishment, at the most moderate charge, that was likely to give the building a chance of its answering the end for which it was built, for a number of years: and, in this view, to rebuild the wall of a greater thickness; and found it as deep into the sand, as it could well be got at a moderate expence; and then to fill the cavity between the wall and the house with Hazlecliff stone. Lastly, to form a sloping Bulwark of the same stone, against the outside of the new wall: after this, with such palliative aids, as prudence should from time to time direct, to let it take its chance, to last as long as it could: and, at any rate, to set up the present temporary high light machine, in the line of direction; as soon as it should be done with where it stood, by the lighting of the houses. In this case, it might be applied as a low light, on an hour's notice; that is, as soon as any accident to the present Low Light Building should make it necessary. This advice and opinion being approved by the Board, the same was put in execution, in the course of the following season.

340. THIS accident did not, however, materially delay the progress of the work towards the lighting of the houses; for at that time the Great Lighthouse was covered in, the windows of the Lantern glazed, the Hearth set, and the balcony rails in their places: so that whilst the interior works were proceeding, Mr. TAYLOR was employing other hands to rebuild and defend the wall as proposed.

341. IT being the anxious desire of the Corporations, and of the trade in general, that the houses should be lighted before the ensuing winter, I thought it my duty not only to forward this, but to give the Board the information, that from local situation I was able.—That in various parts of the West Riding of Yorkshire, there was dug a coal, of the species of the Lancashire Kennel, called here Stone coal, or Cracklers; which burns with a brighter and whiter blaze, than the strong coal of Newcastle and Sunderland\*, and therefore, it seemed to me, would be better adapted to the purpose of producing a light, and could be had at as low, if not a lower, price. The Board were pleased to order me to procure such cargoes of Stone coal, as might be sufficient for a full trial thereof, and which accordingly were procured.

342. UPON the 5th September 1776, the fires were kindled with Stone Coal, which exhibited an amazing light, to the entire satisfaction of all beholders.

As soon as the houses were lighted, I immediately ordered the temporary High Light Machine, which I found sound and firm, to be set upon the walls, that had been built in the direction of the lights; its centre to be 30 yards nearer the Great Lighthouse than the centre of the Low Light; so that its distance from the centre of the Great Light, would still be 250 yards.—These walls, though ordered to be built in length, so as to be only capable of taking the base of the machine; yet whenever it should want moving the walls could be lengthened, and the machine being then got upon rollers, would readily be moved to its destined place.

343. DURING the following winter it was found that sometimes on first lighting of the fires in an evening, the funnels of the Lanterns would not vent the smoke so fast as it was produced by the fires, but it accumulated in the Lantern. The chimneys were then of the same material as the roof, viz. Elland Edge Flag-Stone. Being willing to leave every thing complete, and finding that they would be considerably enlarged by making them of copper plate; the experiment was first tried upon the Low Light, which fully answering the end, the High Light was served in the same manner; and it is so shown in the section of this building, Plate No. 21.

On visiting Spurn Point, the 7th April 1777, I certified to the Board, that the Light-houses at Spurn Point, together with the whole of the works contracted to be done by Mr. TAYLOR, were fully completed and finished.—Upon this visit I had the gratification to find, not only that the lights had given the utmost satisfaction; but that the Court-wall of the Low Light, was

\* As the Spurn lights had hitherto been made by fires exposed to the fury of the wind, they doubtless required a coal of the strongest quality; but as these lights were now to be screened by Glazed Lanterns, a coal that would more freely yield its light seemed better adapted.



likely to endure for some time : for though it had had such shocks, that the light-keepers had felt the tremor in the lantern, yet it remained sound and firm.

344. CONSIDERING the inconvenience that this place suffers for want of fresh water; and that it is likely more and more to become inhabited, on account of the numbers that come on shore from the ships, lying in the Humber as an harbour; on this visit I directed Mr. TAYLOR to sink a well, to try to obtain either fresh water, or that which was so far free from salts, as to answer all subordinate purposes; and to be had in plenty: for here, the tops and roofs of the buildings are so impregnated with salts from the spray of the sea, that the rain water collected from the drippings thereof, is seldom without a very sensible impregnation. The experiment was not likely to be an expensive one, and was ordered in virtue of an observation that had occurred in the course of the work.

Mr. TAYLOR being at liberty to use sea water for wetting his mortar, sunk a well near to each Lighthouse, when he began them; merely to obtain salt water more easily, than by fetching it from the sea at low water; but was much surprised to find, that the water so obtained was but merely brackish, and that in all states of the tide. On examining this circumstance myself, I found further, that the height of the water in the well remained nearly the same, that is, at about the half-tide mark. That at the high water of a spring-tide, when the water flowed within the distance of 20 or 30 yards of the top of the well, the water in the well neither rose sensibly higher, nor was it, to common observation, more brackish; though there was nothing to hold off the sea, but a great mass of porous sand: and on the other hand, when the sea retreated 150 or 200 yards, the water of the well during the time of low water became scarce sensibly more empty, nor did it grow sensibly more fresh.—Reflecting on the cause of this unexpected fact; it appeared to me, that whatever rains or snows fall upon the surface of the Spurn, consisting of about 98 acres, it all sinks into the ground, and therefore must make its way to sea by percolation through the pores of the sand; and in its passage it will by degrees wash off the salts adhering to the surface of the particles of sand at their first deposition: in consequence, this happening repeatedly, the internal part of the Peninsula, which being supposed to have been the longest formed, must have had the greatest length of time to have its salts washed off by the fresh water of the rains, would of course afford the freshest water when sunk into, deep enough to pierce the water bed; and which probably would lie upon an higher level there, than near the border, on account of the necessary declivity for the passage of the water by percolation to seaward.—In consequence of these speculations, I ordered a well to be sunk near the middle of the peninsula; and had the satisfaction to hear, that it answered expectation, being but barely brackish; for that cattle would drink it, and it served every purpose of a family, except for human drinking, and washing of linen: nor could it be expected to be perfectly fresh, as the very rain must frequently have a considerable admixture with the spray of the sea.—It appears then, that though a great mass of sand does not hinder a slow progressive motion by percolation, yet it resists all great impulses, to such a degree, that, in the space of a tide, the salt water has not time to make much progress in return. Attraction of Cohesion, therefore, between the particles of sand and water, seems to perform the office of a Stop-gate, which suffers the escape of the water to sea at a medium height; and, by preventing its speedy return, suffers the downfall waters (like those of a tract of country under artificial drainage by sluices) to have a progressive motion from the internal parts towards their outfall\*.

345. BEING upon a journey to Hull, the 5th October 1786, I went from thence to visit the Spurn, and had the satisfaction to find every thing in order, and completely answering their purpose†.—On this occasion I took a Survey of the Spurn Point, and Plate No. 20, Fig. 1st, is the plan deduced from thence; from whence it appears, that the foundation of the old Light-

\* Had Sir Tho<sup>s</sup> Hyde Packer been acquainted with what had here been done; it seems as if it would have led to an explanation of what he experienced at Landguard Fort in the year 1782: where he found that good water was produced by digging into a sand at eight feet deep, and continued in great plenty to 12 feet deep; but by forcing the well down to 18 feet deep, the water that issued from the bottom became entirely Salt. See his account Philos. Transact. vol. lxxiv. p. 16.

† I must however except the well; the water of which, it was my intention to have examined; and I had taken with me such materials as my chemical friends advised, to have ascertained the quantity of admixture of sea salt in this water. But I was defeated in

ESTABLISHMENT OF THE PRESENT LIGHTS UPON THE SPURN POINT. 191

house, which was wholly within the unbroken land in the year 1771, was now 50 yards without the present border towards low-water mark: not the least vestige of it being to be seen. It was, therefore, by the united testimony of the rescients, who referred to marks, that I was enabled to ascertain its place. In the year 1771, the land where it then stood had a considerable breadth, but now it lies opposite to the narrow Isthmus, which, after extending about a quarter of a mile to the N. Eastward of this site, becomes a naked beach or ridge; over which the sea breaks into the Humber, at high-water, in rough weather, with easterly winds, at spring-tides; and after running about half a mile in that form, attaches itself to a prominence of the main land, from Kilnsey; which was probably the Spurn Head of CAMDEN.—This beach or ridge I found to have nearly the same appearance in 1786, that it had in 1771; only, it seemed to have grown longer, by encroaching southwards, upon the flat area of the Spurn Point\*.

346. ON this visit, the original temporary light great machine was now in actual use; the Low Lighthouse having been for some time demolished, and, at this time, not the least trace left of its foundation†.

347. IN departing from the Spurn this last visit, I was struck with an appearance that I can scarcely satisfactorily account for. I did not leave the Spurn till some time after the Lights were kindled. The Low Light, though in itself a fire of much less bulk than that of the High Light, yet, at this distance, being now a naked light, without the interposition of glass, appeared more vivid and brilliant than the High Light. When I got about three miles off, near Kilnsey, they seemed nearly equal; but when I got to Patrington, nine miles off in a straight line, the lustre of the High Light was greatly superior: in this I could not well be deceived; because, in observing them for a considerable time when the fires were in different states, the brightness of the High Light when faintest considerably exceeded that of the Low Light when brightest: now the query is; If the glass diminished the lustre of the light in a sensible degree (as it must be expected) when near, why should it not do it proportionably at every other distance?

348. I HAD the great satisfaction to find at Hull, that the Spurn Lights were in such credit among the Seamen, that they were by them esteemed (on account of their clear and brilliant light) to be the best Lights in Europe.—It is said that vessels going round the Point, in a dark night, have the shades of their masts and ropes cast upon their decks: that vessels sailing northward gain sight of the Spurn before they lose sight of the floating Light of the Dodgeon, which lies off the great Lincolnshire Wash; and that frequently, the Great Light of the Spurn has been seen, in clear weather, from the high grounds near Beverley, which is a distance of 30 miles.

349. I SHALL close this account by an explanation of the principle whereon the Air-draught of this Lighthouse is performed: which, as I apprehend it is somewhat new, and succeeds well, the curious artist may not think undeserving of his notice.

The air being rendered specifically lighter by the heat of a fire; if from thence it is introduced into a tube or funnel while in its heated state, the absolute gravity of this column is just so much lighter than a column of the external air of equal height, as is due to their difference of specific gravity: and this difference of absolute weight of the two columns, is a positive power by which the lighter one endeavours to ascend up the tube, according to the laws of Hydrosta-

my intention and mortified, by finding that it was filled by bricks and rubbish, so that at eight feet deep, there was no water.—I was told, that as it was appurtenant to no one's tenement, and at a distance from them all; idle mischievous people, who frequently come on shore to saunter about, had amused themselves by throwing things into the water, to judge of its depth, till they had reduced it to that state: and as it was no one's business to clear it, each was willing to shift for himself; though all agreed it had been very useful.

\* This Beach or Ridge has in its appearance some similarity with that of Portland; and, if I mistake not, it is formed, underneath the sand, of blue clay, such as the cliffs of Kilnsey.

† I found on enquiry, that after a repetition of storms, the Court-wall had given way, and an ineffectual attempt had been made to repair it. The main body of the building was soon after attacked; but it stood without the least crack or appearance of settlement, till successive gales had proceeded so far as to take away several of the piles in the Circumference of the base; inasmuch, that, (according to their expression) an Heifer might have been drove under it, among the piles: but after remaining some time in that condition, in one single rough tide, it came down all at once, and the materials were in a great measure dissipated and buried in the sand. The Machine had then been some time in use.

ties.—Now, if the air that is required to replenish the tube at the bottom, to fill up in lieu of what has ascended, cannot enter it without passing through, or so near, a body of fire that it becomes heated thereby, this also becomes successively rarefied; and thus a constant power, or Draught of air is generated.—This I look upon to be the common principle upon which the draught of chimneys and Furnaces depends: the tube of rarefied air being placed above the fire.

In this Lighthouse the principle of Air-draught, or tube of rarefied air, is below the fire: for as the fire must of necessity be exposed to full view, all round; being in a capacious Lantern the draught is cut off, or interrupted, above the fire; so that the funnel of the Lantern must be wide enough to vent all the smoke that is sent up, as we have seen, § 343. In this construction the receptacle for the cinders, being a large tube, over the top of which the fire-grate lies, no air can pass through the fire-grate into the fire, but what comes from the receptacle; the air of which being heated by the cinders, that fall through the grate, has a tendency to ascend, upon the same principle of rarefaction.—This receptacle is supplied by horizontal air-pipes, from the external air: and, that its operation may not be impeded by, but rather receive advantage from the wind; in every direction; the pipes, which are eight in number, are regularly disposed with respect to the compass; and each has a slider to shut up such as would be otherwise a disadvantage. A further explanation of these matters will be found in the technical description of Plate No. 21.



## TECHNICAL REFERENCES TO THE PLATES.

THE VIGNETTE. *The Morning after a Storm, at S. W.*

THE Vignette, as being placed in the title page, on that account claims priority; but in order of description would have come in more naturally in a subsequent place. The intent of it is to give some idea of the nature of this situation in a storm, and the violence of the sea upon this spot. The extraordinary swelling of the wave on the left hand, above the letter A, is doubtless owing to the gradual sloping of the rocks underneath it, as will be more particularly explained in the subsequent Plates.—The wonderful rising of the water, at B, by the stroke of it upon the building, which for the instant totally hides it from the eye, is certainly beyond what might be expected; yet concurrent testimony from Mr. Winstanley's descriptions (§ 17 and 21) down to the present time leave no doubt of the height. This sketch thereof, so far from being exaggerated is much reduced, both in height and bulk, in order that the idea of a building contained therein may present itself.—The gathering of the sea at C is a natural consequence of its being taken up by the south reef of rocks, which are fully described, Plate No. 3, to which I refer, as also to the description, § 317.

PLATE, No. 1. *A General Chart of the Seas surrounding the Edystone Lighthouse.*

The situation of the lighthouse in the chart will indicate its exposure; for, if we suppose a line drawn from the point A upon the coast of France, to the Lizard Point, the distance being about 51 leagues, which may be esteemed the width of the mouth of the British Channel, the Edystone will be found to lie only 15 leagues within this line; that is, less than half the width; and being exposed to all winds from about S. by W. to W. by S. there will be nothing to hinder the ground swells of the Bay of Biscay and of the Atlantic Ocean from coming home upon the Edystone rocks uncontrolled, and even magnified, from the gradual lessening of the soundings. See § 5 and 6.

PLATE, No. 2. *Map of the Coast and Country opposite the Edystone Rocks.*

This Map shows the general situation, and particular distances of the Edystone rocks from the nearest parts of the coasts of Cornwall and Devonshire. The distance of the port of Plymouth being 14 miles, the Newstone or Keystone 11½, and the Ham Head, or perhaps more properly Rame-head, somewhat under 10.

PLATE, No. 3. *A General Plan of the Edystone Rocks, as seen, at low Water of a Spring Tide; comprehending every Thing liable to damage a Ship.*

From this plan it appears from the soundings at low water, that the largest ships may sail between the south and the south-east reef, upon a curve between N. and N. E. or S. and S. S. W. by the compass, according to its present variation of two points west nearly; that is, in case of being inadvertently entangled; here being a clear width of 50 fathoms; but a vessel sailing up or down Channel upon any course from W. N. W. to N. W. by W. or the contrary; and giving the lighthouse a clear birth of 50 fathoms to the southward, will be clear of the north end of the south reef, full 30 fathoms, on one hand, and of the N. E. rock as much on the other; in soundings of about 10 fathoms; and thus, a vessel of any size, in moderate weather, may safely sail within 50 fathoms of the lighthouse; but upon a S. W. or N. E. course, leaving the house on the east, she may safely pass by the building at half that distance.

PLATE, No. 4. *South Elevation of the original Lighthouse, built upon the Edystone Rock, according to the first Design of Winstanley. Taken from a perspective Print drawn at the Rock by Jussieu Johnston, Painter.*

An eye bolt at the landing place for fastening the boats.—B the sloping surface of the rock.—C the foundation or basement, supposed to be of stone; and the horizontal joints of the courses, to be bound round with hoops of iron or copper.—D the store-room.—E the state room (so called in the original) supposed also to serve as a lodging room.

F the open gallery for looking out in fine weather, and supposed intended to let the sea go through in storms.—G the kitchen; supposed also to be used for lodging.—H the lantern, about 8 feet diameter, corner and corner, and 7 feet high. N. B. The ornamental iron work appears to rise near 18 feet above the useful part of the roof. See § 20.

PLATE, No. 5. *South Elevation of Winstanley's Lighthouse upon the Edystone Rock, as it was finished in the Year 1696. Drawn orthographically from a perspective Print thereof, published by himself.*

A represents the rock at low water.—B the landing-place, covered at high tide; and all the time the current runs eastward.

C the entry door.—D F the basement; which, in the fourth year's work, he describes to have been added to the original one of 16 feet; so as to make an addition of four feet in thickness on every side. From the figure it seems, that in the west side at D, it has been a work of stone; the joints appearing to have been covered with hoop plates, as before described of the original base; whereas the east side E has the appearance of having been wood; and to have been bound together with iron strips, as the whole of the superstructure evidently was.

F is the store-room, with a projecting cabin to the south-east.—G the state room.—H the kitchen.—I the open gallery, or platform.—K the lodging room.—L the attending or look-out room.  
M the lantern for the lights, surrounded by a gallery or balcony.—N the flag used for making signals.

PLATE, No. 6. *South Elevation and Section of Rudolph's Lighthouse, completed in 1760. Represented as it stood previous to its Destruction by Fire, in the Year 1753.*

A shows the rock at low water of a spring tide.—B the landing-place.  
a a The steps or flats to which the rock was reduced. b b The branches, c c, &c. Floors of wood laid lengthwise of the steps. d d Floors laid crosswise of the same. e e Courses of compass timber.

D five courses of moorstone; which, with two courses of wood marked E, completed the entire solid. To the top of which led

F the iron ladder, to G the entry door, and through G H the entry or passage, into H the well-hole for the staircase.

K L the mast.—M five courses of moorstone, the height of which composed the entry or passage.—N two beds of compass timber, making all good over the entry.

O four beds of moorstone covered with two beds of compass timber; after which succeeded courses of timber alternately, cross and cross, with compass courses interposed, as shown in the section.

P Q show the upright timbers, or uprights, as they appeared externally, being 71 in number.—p q the same in the section.

r r The store-room floor; and R the door of the store-room; which was so much to the north of the entry, that when the casks and stores were hoisted up perpendicularly by a tackle, suspended from above, they would clear the iron ladder.

S the state room.—T the bed-chamber.—U the Lichen.—W the balcony.—X the lantern.—Y the lantern door into the balcony.—Z the cupola and ball.

f Four curved pipes for venting the smoke from the chimnies in the lantern.—g The top of the copper funnel which passed through the lantern, from the kitchen fire place, which was of brick.

h The upper kent, bevel, or projection of the cornice, for throwing off the sea, to prevent it from breaking the windows in time of storms; which was necessary, though the panes were of ground glass, on account of strength.

i Knees to strengthen the junction of the uprights with the ball on floor, and also in part to support the weight of the lantern.

kkk The original kyles of compass timbers, to form the uprights to a circle, and support the weight of the floors.—m m a Kyles applied, of late years, for strengthening the frame of the building.

n n The lower kant at the foot of the uprights; and o o one of the stanchions by which the kants were fastened down.

p The place where a part of one of Winstanley's chains was jammed so fast, on the destruction of that building, that it there remained, and was shown as a curiosity of the place, during the time of the succeeding structure.

q The natural cave into which the lightkeepers retreated when the house was in flames.

N. B. The technical references to plates No. 4, No. 5, and No. 6, were inserted in the body of the work; which the author thought right no longer to encumber therewith; but are here inserted, to preserve the regularity of this part of the work.

The detached figure 2, shows the manner of jointing the five courses of stone marked D (fig. 1a) where n K shows the mast, and a a the places of 8 upright bars; b b being supposed two more of the same nature. The black lines show the joints of the first course; the dotted lines those of the second; and so alternately.

Fig. 3. Represents the manner in which the courses of the bed of moorstone M (in fig. 1a) was jointed; wherein K is the mast; a a b c d the well-hole, and e f g h the entry from the iron ladder into it. The jointing of the courses in this bed also, were alternately according to the black and the dotted lines.—This figure may also serve to describe the courses of the bed of moorstone O, if the passage is supposed, omitted.

PLATE, No. 7. *A Plan and perspective Elevation of the Edystone Rock as seen from the West. Taken from the Model thereof, § 97, 121. Showing also the Theodolite.*

The representation is as I found the rock; Fig. 1. being the plan, and Fig. 2. the upright view. The same letters refer to the same parts in both, the lines upon the plan shew to the cardinal points, E. W. N. S. according to the true meridian.

L is the landing-place, and C the summit of the rock; the general declivity being towards the S. W. the grain of the laminated moorstone that composes it being nearly parallel thereto. It has, however, considerable irregularities; for upon the line A B the rock makes a sudden drop of 4½ or 5 feet (§ 7.); and by over-hanging to the westward, when there is a ground swell at S. W. the sudden check causes the sea to fly in an astonishing manner, even in moderate weather.

The surface of the rock is shown, as supposed to have been for ages past; except where it is visibly altered by man's hand, chiefly within the circular area of the late building. The flat trends of the steps cut by Rudolph are marked D; the upright faces of the steps F; and E denotes the spawled parts, parallel to the grain of the rock.

a b c d e f g h show the remains of the courses of timber of the 12 great

level by Wistendley; of which the stump of one only,  $\sqrt{x}$ , that at  $e$ , remained for my inspection; it was run in with lead, and had continued fast, till in planting a dove-tail there, it was cut out and found chloride; see § 39. Which of the other holes, that are left unmarked, made up the remaining four, I could not make out; as doubtless several of them appertained to the additional work that he fixed in the 4th year (§ 41).

Fig. 3. shows a pair of Ruden's iron branches (§ 36, 39) to a scale three times larger than that of the plan, wherein A B is the main branch, or dovetail part, C D the key, driven hard in, but without touching the bottom, their depth in the rock is denoted by supposing the line E F its surface. The holes in the branches served to fasten the timbers, by large bearded spike-bolts.—Of those branches I traced 25 original parts, of different sizes, and two more modern; their places are shown in the upright, Fig. 2, by inspection, and likewise in the plan, Fig. 1, at 1, 2, 3, 4, 5, and 6, 7, 8, 9, 10, &c. forming a double circle; also two pairs of them at  $k$  to fix the mast, on two sides, to the centre. The iron that remained in the rock, are distinguished in the plan, by being hatched with slant lines, the empty holes or cavities by being black. Those that remained whole, whether fast or loose, are distinguished in Fig. 2, by their  $g$  or  $h$ .

$\lambda$  shows the place of the cave on the east side; and R a strong ring bolt, put into the rock on the recommencement of the building in 1757, for fastening the western guy-rum of the shrou.

In Fig. 2.  $rstw$  shows the three-legged stool (§ 97) steadied with cross braces. Upon the middle of the upper round plank  $st$  was screwed down the thread-like T, to whose index was screw'd the long horizontal rule T S, divided into feet, inches, and parts upon one edge, tending to the centre.—Upon any marked point of the rock to be ascertained, suppose  $v$ , the rod  $xy$  was set upright by a spirit level, and was preserved in an upright position by two small signs of deal, applied as shores or struts, in two different directions. The dovetail edge of the rule, being brought against the upright rod, was shovelled up by a staff held in the hand tight against the rod, till a spirit level laid upon the top of the rule, showed it to be level. In this position the index would show the degree and minute of the circle; the upright rod would mark the distance from the centre upon the rule; and the rule would mark upon the rod, how much the intersection was above its bottom at  $x$ ; see § 97.

PLATE, No. 8. South Elevation of the Stone Lighthouse completed upon the Elystone in 1759. Shewing a Prospect of the nearest Land, as it appears from the Rock in a clear calm Day.

A the landing-place.—B the cave in the east side of the rock.—C the steps cut to mount the rock to the entry door.—D an iron rod, serving as a rail to hold by, in passing to the foot of the ladder, occasionally put out from the entry door to E.

Over the letter F is a view of the land about Whitby-Bay. Over G the Ram Head.—Over H Reading-Point.—I St. Nicholas, or Drake's Head.—K Brimstone.—L Garrison of Plymouth. M Plymouth Town.—N Saps in Plymouth Harbor or Mount Phoenix. P Ships in Catwater.—Q Middledown Point. N. B. The cascade shown to the left of F must be supposed momentary; and, from the iteration of the water, the next moment to set the contrary way.

PLATE, No. 9. Section of the Elystone Lighthouse upon the East and West Lines, as relative to No. 8. Supposing it the low Water of a Spring Tide.

In the section of the rock, A B shows the upright face or drop, marked with the same letters in Plate No. 7, and the line C D shows the general direction of the grain, and slope of the rock to south-westward. The dotted line  $ab$  shows the level of the base of the first stone. The black line  $cd$  is the base of the stone in the first course that is intersected by the E and W. Line and  $ef$  is the level, of the top of the 1st course, and lod of the 2d, 3, 4, 5, and 6 mark relatively the tops of the six courses that bring the artificial part of the foundation upon a level with the reduced top of the natural rock;  $ef$  being the first entire course, marked VII, as being the seventh above the ground joint— $g$  is the foot of the temporary ladder; and there is shown the manner in which the ground joint of the stone-work was sunk into the rock, all round, at least three inches.— $h$  shows the first marble plug, or central joggle, that went through the 5th course, and reached half way through the 7th; and so on, in succession to the top of Course XIV.

$ik$  in like manner show the place of the marble cubic joggles inlaid between each two courses, which were in an octagon in disposition round the centre, of smaller cubes between the 5th, and 6th course.

Course XIV, terminates the entire solid; as upon it is pitched the entry and well hole for the stairs.—The temporary ladder  $fg$ , to the entry door D, is only put out when wanted; and then is locked by eye-bolts to the stone, at other times, having a joint in the middle, it folds, and is laid along in the  $cd$ .

Above the top of the entire solid, the centre stone being omitted to give space for the well, the cubic joggles were of double the number, and laid the size.—Course XXIV, terminated that part of the building called the solid, and here the habitable part of the building began, wherein E is the lower store-room.

F the store-room door.—G the upper store-room.—H the kitchen.—I the fire-place, from which the smoke ascends through the flues and lantern, through a copper funnel, as per section, and through the ball.

K the bed room. L the stone basement of the lantern.—M the lantern door into the balcony, and N the cupola.

The ascent from room to room is by perforations through the middle or key-stone of every floor; and the detached figure shows the means, by inclined step ladders, removable at pleasure.

PLATE, No. 10. Plans of the Rock after being cut, and prepared to receive the Stone Building. Shewing the six Foundations Courses.

Fig. 1. Plan of the rock, as prepared for the stone-work, somewhat extended to show how it appertains to the plate No. 7. The line A B shows also here the place where the surface drops, as specified No. 9.

In this figure, Course I, appears in its place, as fixed with its trenails and wedges, § 238, 239. The part darker shaded, and marked D D, was not reduced to a dovetail on account of features, but was sunk two inches lower than the rest of Course II. The stones laid thereon would therefore be encompassed by a border, and held fast in every direction. The letters E, W, N, S, in all the figures denote the cardinal points; the same letters in every figure denoting the same parts.—The part of the rock marked C, rises above the rest by an ascent or step of 15 to 18 inches, according to the line F D G E; which, lying somewhat without the general contour of the building, and affording a

firm abutment, the advantage was taken, and the work of the 1st and 2d course carried against it, as shewn at G.

No. 1, 2, 3, 4, 5, 6 show the level platform, or steps, for the different courses, whose upper sides are even with these numbers in Section No. 9. No. 2 being upon the level of Ruden's lowest step.— $\lambda$  denotes a piece of stone engrafted into the rock; serving as a bridge to cross a chasm, opened by cutting down the top of the rock to that level, into the cave. Out of this stone is formed a part of the border that encircles the work.

Fig. 2. shows how the buttress G was terminated in the 2d course. It also shows the places of the trenails and wedges, which in all these figures are shewn in the same manner. The dotted lines every where refer to the course that is to come on; and shows how it will break joint upon the course supposed laid.

Fig. 3. shows how the space III K, in Fig. 2. is filled up in Fig. 3. being confined in, by the rise of the step L at H I, and the cramps  $a$  and  $b$ ; the ground proving here irregularly shattered by cutting the steps for the former lightness.

Fig. 4. shows the structure of Course IV, where in this, as all the others, the stones lighter-colored denote the Portland, the darker the moorstone.

Fig. 5. shows the position of three joggle holes Y, betwixt this course and the next above.

Fig. 6. shows Course VI, complete, which brings the whole work to a level with the reduced rock; it shows the joggle holes for the eight cubes, and the central plug joggle, fixed in place at O, ready for the reception of the centre stone of the next Course No VII.

PLATE, No. 11. Plans of all the different Courses from the Top of the Rock to the Top of the Balcony Floor inclusive.

Fig. 1. is the proper plan of Course VII, relative to the Section, Plate No. 9. As being the first entire course, the trenails and wedges are shown, but afterwards omitted in the draughts, to prevent crowding the figures. The black lines and dotted lines shew the joints of the alternate courses. The centre stones, and the four stones surrounding, were alternately of the same size in the top of Course XIV.— $a$  is the centre plug, first set;  $b$  the square part of the centre stone; from each of whose four sides a dovetail projects, and thereon are fixed the four stones  $c$ , by joint wedges and trenails, as per figure; which by stones united, make one stone, sufficiently large to receive eight smaller dove-tail stones  $dd$ ; and whose projecting parts form dovetails to receive another circle, or order of stones, even like the former. The cubic joggles are shewn at  $e$ .

Fig. 2. gives the plan of the XIVth Course, ending the fundamental solid, and on which the entry and well-hole are begun. It also shows the diminution from Course VII. Upon this figure is shown the distribution of the smaller cubic joggles, which take place upon the 1st entire solid. The entry here appears to have a small declivity with the E, and W. line, which was not noticed in Section No. 9, to avoid ambiguity.

Fig. 3. is the plan of Course XV, being the first of the entry door and well course.

Fig. 4. is the plan of Course XVIII, shewing the work of the entry closed in, and the solid returned. Also the manner of lock joining the four stones round the centre to each other; watch in the course below the entry door, were united by dove-tails to the centre stone. Joint wedges were applied in the hook, as per figure. Thus the arrangement, in circles from the centre, was again complete. In the entry courses, as every part had at least one cubic joggle and two trenails, the work was secure against all ordinary attacks of the sea; the weathers being on the east side; but when capped and bonded together by this XVIIIth Course, the whole was again considered as one entire stone, out of which the cavity had been cut.

Fig. 5. shows Course XXIII, ready for putting on the cap course of the solid.

Fig. 6. gives the cap course, making the store-room floor, in its finished state; the first course of the habitable part of the building, viz. Course XXV, being upon it; and shewing the store-room door, with its joggles, joint stones, and cramps.—The detached figure, relative to  $n$ , shews a part of the top of the wall of Course XXV, in a triple scale; wherein  $aa$   $ii$  denotes one of the pieces of stone, whereof I have completed the circle;  $f$  shews one of the joggles used in this part of the building; being slices of marble the size of a common brick, let half its thickness into the middle of the stone, so that the next course above, breaking joint upon the middle of this, according to the dotted line  $gg$ , half the joggles length will take one of the upper stones, whose joint comes upon it, and the other half joggle, the other by which means every stone is fixed in its place, as it were, by two steady pins, one at each extreme. The black lines  $hh$  shewing the joint at each end of this stone, the small lozenge figures  $k$  and  $l$  shew the shape of grooves, cut from the top to the bottom of each end of each stone, and which, when two are joined together, form that figure;  $k$  denotes the lozenge empty, or unfilled, and  $l$  the lozenge filled with a joint stone. See § 272, 273.— $m$   $n$  shews the shape of one of the cramps, in upright; and  $p$  as seen upon the flat. The holes in the stones at  $q$   $r$  are bored, to receive the round shanks of the cramp, and the rectangular cavities  $q$   $r$  are sunk, to bury the flat of the cramp  $p$ .

Fig. 7. gives the plan of the kitchen floor, and the upper bed of Course XXIX, last executed; shewing one of the endless chains; of which, as appears in Section No. 9, there are two to each floor. The detached figure shewing an enlargement of the chain, and groove that contains it, will need no comment, after perusal of § 274.—In the principal figure the dotted lines at  $x$  shew the place of the fire grate;  $tt$  the sink;  $u$  the dresser;  $v$  the settle,  $z$  a place for a claw table; leaving a vacancy to the window between cramps § 30.

Fig. 8. is the plan of the bedchamber, taken upon the top of Course XLIII, which gives the horizontal sections of the windows.— $yy$  shew the places of the three cabin beds for the lightkeepers, § 244.  $z$  The hole in the floor for the copper funnel from the kitchen, and  $a$  shews the place of the clock. In the detached figure,  $bb$  shews how the cramps are disposed in the reduced jambs of the windows.  $c$  shews the  $p$  and  $n$  of the rabbit, to receive the shutters or ports of the windows, whereas the uprights are seen in Plate No. 8 and 9.  $d$  shews the sill of the clear opening against the solid of which, the window frame  $ef$ , and sashes are lodged; the whole of which go in together, and are held in by wooden pins, two above, and two below, as shown at  $g$ , the holes being bored in the solid stone. If these pins are cut off, the whole can be drawn out and renewed, without injury to the stone work. The joint of the wood frame with the stone work, is secured against wet by white lead  $h$   $i$   $l$   $o$ .

Fig. 9. shows the plan of the cap of the main column, being in Plate No. 9. the XLVth Course, and composes the balcony floor.  $aa$  shews the mahule in the centre correspondent to the other floors; the funnel hole accordant with  $z$  in the last figure. The dotted lines  $kk$  trace out the octagon



difference afterwards, arose from finding less area upon the rock; and the necessity of size and convenience in the habitable rooms.

PLATE, No. 14. *A View of the Rock on the East Side; and of the Work advanced in Course XV. the first of the entry Courses; shewing the Manner of landing and hoisting the Stones, &c. in every after Stage of the Building.*

Fig. 1. shews the boat Weston in the Gut, delivering her cargo; PQ shew the two fender piles, to prevent her rubbing against the rock. C the landing-place. X The cave, here seen in front. D The gully, through which a momentary cascade makes its way; and which was proposed to be stopped, \$ 100

EFG The shears; from the head of which are suspended the main tackle blocks A B, whose tackle fall, after going to the snatch block E, passes to the windlass, or jack roll, whose frame being of iron, is fastened to the rock, as per figure.—The enlarged detached figure a, shews the frame and roll frontwise, as seen from the snatch block; b shews the side view thereof, the roll being seen endways; c shews the manner of coupling the back stay to the upright stanchions; and d shews, by a figure still more enlarged, the upper end of the stanchions for receiving the gudgeons of the roll.

While the stone is hoisting, the man represented at I is heaving in the tackle fall, of the runner and tackle H K: for, till the stones are cleared of the boat, the shears lay out considerably, and the out-bawler guy tackle L M is slack. Thus crosses the Gut, and is fixed by a ring bolt to one of the rocks of the south reef. By such time therefore as the stone is hoisted by the main tackle to the height of the entry door, the shears are got into the perpendicular; and then by easing the out bawler guy tackle L N the stoce comes into the entry door. —The runner and tackle H K is hooked to the guy chain O, which crosses the water, and passes down to the ring on the west side of the rock; marked R in Plate 7.

In the detached fig. 2, the anchor-like piece of iron by which the main tackle blocks are hung, is shewn to an enlarged scale at *a*, *b*. Thus arranged, suspended upon a round bolt at *e*, and passes through the tops of the two small legs, swings freely between them, and always putting itself in a perpendicular position and producing fair bearings upon them, without any unnatural strain or twist, enables them to support the greatest weight possible.—In like manner the two arms of the anchor *g*, *h*, having the two guy tackles hooked to them, the action of those tackles is upon the suspending bolt, and the feet of the shears turning freely upon eye bolts fixed in the rock, they are at liberty to conform themselves to the position wanted; so that the stress upon the legs is always

[illegible]

In this manner all the heavy materials were got up; the moveable shears rising with the work, till the cupola was to be set upon the lantern.—The 6th stage shews the apparatus used for this purpose. See § 300. The great shears being now done with, were taken down and put through the windows of the uppermost room, and there, being well steadied, served as booms. The de-

tached figure S bring the plan of this stage, shews their particular disposition; wherein *op* shew the places or feet of the legs of the shears used for this particular purpose; also marked with the same letters in the relative upright. In this the rope *qr* shews a side stay to the leg *or*; and *st* is the stay of the leg

7, each fastened to  $y_3$ , the extremes of the booms.—From each end of the cross-tree at the head of the shear poles proceed the ropes  $wx$ ,  $yx$ , which joining in one gay rope at  $x$ , proceeds over a pulley in the end of the temporary timber at  $z$ : from thence, with the intermediation of a tackle 1, 2, it proceeds to and fastens to the main cross-tree at  $z$ .

to, and brace it at the extreme end of the boom 3; and as the weight to be hoisted there is considerable, the main shears 1, 2, are placed on the main beam 4, and principally lay on this guy, the stay or shroud rope 3, 4 is passed from there to the pulley 5, and the window of the room below, and is there fixed.—It is now plain, that by the tackle 1, 2 the shears can be let go over as far as necessary, and brought back into the perpendicular; but to counteract this main guy, and keep all steady, the rope 6, 7, with a small tackle 8 upon it, performs the office of an out-hauler guy, fixing to the same ring in the rocks, as that of the main shears had before done. This apparatus enabled the cupola to be hoisted and set on whole without a brouse.

PLATE, No. 15. *Explanatory Shewings of particular Parts comprehended in the foregoing general Description.*

Fig. 1. The phyllotaxy of larval work, at each angle of the lantern, to its full size. ABB the line of the insoule, and CDD that of the outside of the lantern. The angle of the light ray, and the angle of the lantern, are of two constant nature, and the angle of the lantern is the angle of the lantern. The contours of the cast net, and *drilling* shows the path of the claw cast out each side at each end, and the *sewa* 1.1. In each *sewa*, *sewa* 1.1 to screw down the pairs upon their respective lars, and unite them a, together, and are the same at top as bottom. The corner pieces at *sewa* 1.1, being screw on, while the pairs were fixed, served to unite the cast together, at 1.1. The quadrilateral space, *sewa* 1.1 being cast lower on the side *sewa* 1.1 than the opposite, *sewa* 1.1 at the dog head of the angle lars upon the slope, without danger of being

erks, being of the belief that for progress and success

\* A suffix code commonly consists of a pair of double brackets, bearing the label (code) for program data bases.



displaced. The dotted lines  $xyz$  show the inside, and  $y$ , the outside of an horizontal section of the glass plates;  $x$  is a hinge the rabbit in which they are lodged.  $ac$ ,  $b$ ,  $1$ ,  $2$ ,  $e$ ,  $n$ ,  $1$ , show the section of the border, that goes round the circumference of each shaft frame, and that, by screws of copper, represented at  $G$   $G$ , the border is fixed to the fluted border of cast iron  $ef$ , which surrounds the face of the pillars.  $3$ ,  $4$ ,  $5$  show the inside, and  $3$ ,  $6$  the outside contour, of the ribs or shaft bars, which join the border as shown at  $b$ ,  $2$ ,  $5$ ,  $a$ ,  $6$ ,  $6$ . The detached figure  $X$ , as in No. 12, is a section at large of one of the window bars; the point  $4$  being supposed to be placed on the point  $5$  in the main figure.

Fig. 2, is the upright corresponding to the Plan, (Fig. 1) wherein  $ABB$  is the upper, and  $CCD$  the under side of the grounded bars.  $DBX$  is the elevation of the corner; and  $DBXYZRS$  shows the upright of one of the faces of the pillar and claw, and the corresponding dotted line  $rs$  shows the extent of the project  $g$  border, whose section is marked  $ef$  (in Fig. 1).  $GH$  shows two of the screw-holes for the small copper bolts, that fix the border of the shaft-frames to the iron flanch border of the pillars.  $EF$ ,  $FF$ , the two screws by which each claw is fixed.  $xy$ ,  $z$ , shows the inside of the upper border, and  $x$ ,  $z$ , the extent of the rabbit; the space  $PAQ$  at top and bottom, is an enlargement of the breadth of the border, to make all good to the class, and the iron border is made good between the claws by the square bar marked  $O$ , both in this figure, and the Plan, (Fig. 1) which is riveted upon the grounded bar; and perforated horizontally for the copper screws.

Fig. 3, The iron fire grate of the kitchen, which perfectly vents two smoke, and warming the room above, is given to an enlarged scale. The detached figure below it, is the plan of the upper bar; the lowest being straight, and the intermediate ones rounded to them.

Fig. 4, gives a section of the socket for the candles, and  
Fig. 5, that of the lamps, both to their full size.

PLATE, No. 16. Mr. Jessop's Draught, by which the Yards were built for the Edystone Service.

As that I think it necessary to remark upon this plate is, that the original drawing from whence this is copied, was so ancient for the direction of the haul-bulld, and that those yards answered well in a short hollow sea.

PLATE, No. 17. Plan and Description of the Work-yard at Mill Bay, with its Paravane and Vessels.

Fig. 1. The general Plan of Mill Bay, wherein the dotted line  $abc$  shows the line of low water spring tides.  $de$  The channel dug from low water to connect vessels to the head of the jetty  $fg$ .  $hikl$  The area of the work-yard. Since the removal of this work, has been built  $L$  the long room;  $B$  the balls,  $AC$  the same larracks, and  $DD$  new streets of Stone-houses.

Fig. 2. Plan of the work-yard and jetty.  $ABCD$  is the line terminating the head of the channel. Now any vessel lying against the two large piers  $BC$ , on which a pair of shears being erected, can be unloaded of her cargo of stone, and delivered upon a wheel carriage; that passing along the jetty to the turn-out.  $E$ , the carriage is there turned; and it becomes full with the rail-road  $EF$ , and passing along it, enters the work-yard, whose boundary is marked by  $G$   $G$   $G$   $G$ .  $AI$  is a smaller turn-out, which enables the carriage to go on with its burden; either in the straight line, or to turn there and go along the rail-road in the middle of the yard, and arriving at any destined point, suppose  $H$ , is there met by a coal carriage; for which, planks being temporarily laid, as at  $I$ , the coal is being transferred on small rollers will be easily moved thence, to the extremity of the yard sideways, and thus stores can be deposited, as at  $K$ , (shown edges upwards) upon any point of the area of the yard, and returned by the same means. § 167. Note 4, p. 104.

The area bounded by the Line  $G$   $G$ , and the dotted line  $L$ , is the Portland workshed.  $M$  denotes one of the bakers; to which, from the wheel carriage (supposed on the rail-road opposite) strong points being laid, as shown by the dotted lines, the pieces of stone are brought on small rollers; the bakers having rollers sink thence, to receive the ends of the joists.—In like manner, the area  $NO$  was the shed for the muscovite workers.

The square area  $PQ$ , denotes the extent of a roof supported by four posts covering the platform; whereof  $ab$  represents the platings of rough stone walls;  $cd$  one of its principal floor timbers, 5 by 12, these being covered with three-inch planks, and brought to a true level, made a stout floor, upon which the courses were brought together, § 167.— $R$  the cabin for the foreman of the yard.  $S$  a small store-room for tools and iron work.  $GW$  the store-shed for Watcote lime and pozzolana.  $VX$  the shed for burning or beating the large parts of the pozzolana upon  $WY$ , the bank is with three cast iron beds upon it.

Fig. 3. Supposed a detached figure, being the ground plan of the turn-out at  $T$ , (Fig. 2) to an enlarged scale, wherein  $AB$  is a dormant circle of wood, well supported; of which  $C$  marks the centre pin face in the transverse beam  $DD$ .  $EE$  being connecting studs.  $FF$  are portions of the rails, wherein the wheels move, which are kept in place by the filets  $ff$ , nailed on each side.  $G$   $G$  shows the sleepers for supporting the rails at about a yard's distance middle and middle; as is also shown near  $E$  in Fig. 2.

Fig. 4, is the plan of the movable turn-out, and Fig. 5, the relative upright; showing also the section of the dormant circle. The three last figures having a mutual reference, the same parts are marked with the same letters, and furthermore, in Figs. 4 and 5.  $HI$  I show the rail part of the turn-out, corresponding to those parts marked  $EF$ , Fig. 3, in width and height. The rail parts  $HI$  are strongly framed upon the cross beam  $KN$ , and connected by the pieces  $L$ ,  $L$ . The whole being poised, with its burden, upon the pin  $C$ , but without absolutely touching the dormant circle  $AB$  while turning; for bearing only upon the flat shoulder of the pin, it turns easily; but, when it is leaning on or wheeling off, the equilibrium upon the pin being destroyed, the ends  $HI$  are then supported upon the dormant circle, and the wheels will move steady.

Fig. 7 shows the plan, and Fig. 8, the upright view of the wheel carriage to the same scale as that of Fig. 3, 4 and 5. —Also Fig. 9, and Fig. 10, give the upright views of the roll carriage in two directions to the same scale; which show distinctly the manner of supporting the axis of the rolls on iron frames; and how the iron frames are kept upright by four pairs of cross rails.

Fig. 11, gives the upright of the capstan roll, axis, and middle part of the last to the same scale.—At  $1$ ,  $2$  is shown the capstan in full, to the scale of the yard; and  $3$ ,  $4$ ,  $5$  mark the direction of the rope; which, from a snatch-block at  $6$ , ascends to the upper block of the main tackle, suspended from the top of the shears; as per Fig. 6, wherein the in-mauler guy tackle is marked  $7$ , being a runner and tackle, and the out-hauler marked  $8$ , are simple blocks.—The guy-rope  $7$ ,  $6$  was attached to a ring-bolt, passing through a large rough

stone, rammed into the ground; its place being shown at  $6$ , (Fig. 2) the out-hauler guy  $8$ ,  $9$  being secured in the same manner. —The marble cocks marked  $10$ , go round the point of the Bay.

Fig. 12, is the elevation of the upper part of the jetty-bank in front, with the shears upon it, to an enlarged scale; more particularly to show the smaller parts.  $A$ ,  $B$ , the front pair of piles to which the cross beam  $CD$  is halved; and in like manner to each pair of piles.  $E$ ,  $F$  the ends of the longitudinal half balks;  $V$   $F$  the cross joints;  $G$ ,  $G$  the ends of the flat rails that the wheels of the carriage run upon;  $H$   $H$  being a single cross timber serving as a stop to the carriage at the end.  $I$ , the snatch-block.  $N$ ,  $B$ . The scantiags are marked, because, this jetty or scaffold, erected as slight as might be for a temporary purpose, sustained the whole tonnage of the Edystone matter, in and out, without derangement. The detached Fig. 13, gives a part of the top of one of the shear legs, showing how they were plated on each side, to support the block of the anchor from bending; and thereby from splitting the poles.—Fig. 14, is the enlarged figure of the runner and tackle (marked  $7$  in Fig. 6)  $K$ , the number-block, of one large single pulley;  $L$ ,  $M$ , the tackle-blocks of three pulleys each, making a purchase of twelve, equivalent to the great blocks. (See the Foreword.)

Fig. 15, gives an upright diagonal view of the main tackle blocks; having six pulleys each upon two pins; the larger tier being ten, and the lesser eight inches diameter. This figure distinctly shows the method of advantage stopping; being double, that the pins being readily knocked out, they could be frequently greased without trouble.— $N$ ,  $B$ . The shears, blocks, and tackles used at  $MI$ .— $Bay$  were nearly the same as at the rock, and one pair of main tackle blocks at each place, with the same pulleys, were though the whole service; but the pins were renewed each season, and sometimes often, being of wood on account of the salt water; and were frequently greased. The main tackle block at each place was no larger a rope than of three inches circumference; being a white rope, remarkable soft laid, hawser-fashion, and which is of material consequence.

PLATE, No. 18. Descriptions of supplemental Matters, having Reference to the Edystone Building.

Fig. 1, contains an upright front view of the great tackle, or purchase—blocks of twenty sheaves or pulleys, numbered  $1$  to  $128$ .

Fig. 2, A side view of the same blocks, referring to Fig. 1st. The advantage of this construction is, that the tackle-bolt or running rope may be reeved through the twenty sheaves, without a cross or interference; so that the standing part, or beginning, may be in the middle of the upper block; and the ending, hauling part, or fall, upon the middle pulley of the same block. The weight therefore being suspended by twenty ropes instead of six, as in common triple blocks, the tackle fall, as relative to a given weight, may be lesser or fewer yards in the same proportion; which renders the whole much more flexible and pliant, and which, together with the advantage derived from the mode of reeving, occasions their running and falling nearly upon a parallel. The uses and advantages of these blocks, and also the method of reeving, are more particularly described in the Philosophical Transactions, Vol. 47, for the years 1755 and 1756, and are now so well known, that I shall not just touch upon the principle, wherein the reeving is performed. Beginning in the middle, the greater sheaves are reeved as far as can be on them; from thence going to the first of the smaller sheaves, and reeving the whole of them throughout, you then go to the first of the greater sheaves, before left unreeved, ending upon the middle sheave of the upper block; and thus arises a diminution of the friction from the more equal distribution thereof.

Fig. 3, shows an upright section of the store-room to an enlarged scale; in it is shown the centre whereon the upper store-room floor was turned; and in like manner the rest.

Fig. 4, is the plan relative thereto, the letters being common to both.  $a$ ,  $b$ ,  $c$ ,  $d$  show two of the six circles, formed to the circle of the vault of the floor. These ribs are connected at their ends by two wooden rings,  $e$ ,  $f$ ,  $g$ ,  $h$ ,  $i$ , the former supported by four posts, three of which are shown in their places; and the latter by eight, of which only one is shown on the right hand, and one on the left, to avoid confusion. The rings are each made to take asunder, that after straking the centre they might be got out of the room.—At  $kl$ ,  $m$ ,  $n$ , two of the ribs are supposed taken out, to show their bearings upon the rings; they were open centres, that it might be seen underneath when the joints were fair. Fig. 7, of Plate 1, shows the 16 ribs of stones would apply to the 16 ribs. In this plan, Fig. 4,  $A$  shows the well hole, and  $B$   $B$  the cross timbers for supporting the four middle posts, whose places are marked out by dotted line squares.

Fig. 5, is an elevation, and Fig. 6, the relative plan of a dial stone, taken professedly from the general figure of the Edystone light-house; being the design of the late James Duke of Chesham; and by him erected at Amesbury, Wilts, with a dial upon it, by Mr. Ramsden.—The drawing, of which this is a copy, was given me by the Duke; and is placed here as an instance, that the Edystone column may be applied to some uses of architecture.

Fig. 7, represents one of the silver medals, given to the seamen as a token of the service, § 177.

Fig. 8, shows the tool wherewith the stones were got up from the bottom of the Gut, mentioned § 238.  $A$ , one of the stones with two trenail holes, as per § 176.

Suppose this stone lying flat in the bottom of the Gut, the side  $A$  uppermost. The tool has a pole or staff  $ab$  about twelve feet long, sufficient to reach to the bottom. The single prong is forged to a very gentle taper, such as to be thrust eight or nine inches into a trenail hole (all of them being bored to a gauge) it can be driven by the pole, till fast; observing that the arm  $c$  corresponds to the centre of gravity of the stone. The water is generally so clear as to see the bottom; and in case of any ruffie by the wind, can be in a great measure freed from agitation, by looking through a speaking trumpet, whose mouth is put down eight or ten inches into the water. The rope  $de$ , being then set upon by the main tackle; instead of its drawing out, the length of the arm  $c$  causes the prong to jump to the side of the hole; and the stuff being guided by the hand, with a comb to hinder its flying off too far, the whole assumes the position of the figure; and when brought above water, is lowered into a yawl.

Fig. 9, is a section of one of the mortar buckets, and in it the beater. This figure will not be further explained, than what is said § 257.

Fig. 10, shows one of the internal faces of the lantern's glass frames, to the same scale as Plate No. 18, and therein the cross bars of iron as they were actually fixed according to § 306 and 307.—Beside the flat face of each bar, distinguished by a darker shade, and through which the screws passed; each end was also cranked about an inch, so as to set the transverse part of the bars, clear of the copper shaft frame; and they were cleared of each other at their intersection, by one of them being made straight, the other curved so that

\* A rope laid hawser fashion is a rope consisting of any number of yarns according to the strength required, which divided into three strands, and each being twisted equally, are prepared to be laid into a rope. But if this, or any similar rope is further twisted, equally with two others, so as to make three strands, these will form a rope, said to be cable laid.

part. This figure is less regular than what is shown Plate No. 12, yet I do not look upon this assemblage as less capable of resistance to external violence, or less useful in regard to the transmission of light; for all the panes being taller than the candles, the chandelier rings are so hung, that when the candles are at rest, disposing their light, that of one chandelier passes through the range of panes A, and that of the other through the range B; and when the candles are snuffed, one of the rings of lights being seen through the range C, the other mounts to D, and vice versa.

Fig. 11, shows the chain of triangles, from the Edystone to the flag-staff of the Garrison of Plymouth, for ascertaining their distance transversally.

Fig. 12, is an enlargement of the work within the Headlands of the Sound; the same letters marking the same points in both: whereof E denotes the Edystone, H Ramhead, M Maystone, or Mewstone, P the triangular tower on Point Peles, S Stationary battery house, W the western temporary beacon, G the eastern upon the glacier, near the west bastion's turret, B a station at the middle of the base, F the Garrison's flag-staff.

The whole country about Plymouth Sound being very uneven, I could not readily obtain a base better, than by very carefully measuring the two lines BC, BW, taking the intercepted angle WBG; whence the right line WG was obtained, making a base of 1471 feet, and which I cannot suppose to err more than half a foot. Again, the nearest place from whence the two beacons W, G could be commodiously seen for the purpose, was the point S; and all the angles of the triangle WSG being likewise carefully taken, I conclude the angle WSG, to be  $107^{\circ} 43'$ , taken true to a minute; that is to say,  $\frac{1}{2}$  part of the whole angle. The line SW could therefore be determined within  $\frac{1}{2}$  part, which being considered as a new base of larger extent, may be esteemed true within  $\frac{1}{2}$  part of the whole. From this, and the angles taken as marked upon the scheme, the lines W, P, M, and W, E, were successively determined, and finally F E, the distance of the flag staff from the Edystone, came out very near, but somewhat less than, 14 miles.—But the interior harbour of Plymouth, called Sutton Pool, being about three furlongs farther from the Edystone than the flag-staff, the whole distance may be esteemed 14½ miles from Plymouth Harbour.

PLATE, No. 19. A Map of the Coasts and Country near the Spurn Point.

It appears that this coast, from Flamborough Head, or at least from Bridlington to the Spurn Point, trending S. E. (near merid.) and the tide of flood of the German Ocean setting strongly to the southwards, this will cause these flood-tides, when agitated by all winds from N. N. W. to N. E. to bite very hard upon this stretch of coast; and, no part of it being rocky, to wear away; the sand and matter dislodged to be driven towards the south, forming at the tail of the spit, the assemblage, called the Spurn Point, § 337. Doubtless this matter so brought would in time block up the Humber, were it not for the powerful re-flow of that river's tide, aided by the fresh water from the higher country. The Spurn Point being therefore the effect of a struggle between the sea tide of the German Ocean and the re-flow of the Humber, we are not to wonder if the powerful effort of the sea by degrees drove the channel of the Humber southwards towards the Lincolnshire coast, thereby giving opportunity for the Spurn Point to lengthen towards the south, § 340, and, as the coast wears away, to which it hangs as a rudder, to be also in a state of travel westward, § 336, and 338.

PLATE, No. 20. Plan of the Spurn Point, as in 1786. Also its Variations during the preceding twenty years.

Fig. 1, is the plan of the Spurn Point, as taken in the year 1786, comprehending about 98 acres; upon which little needs to be said, after what is upon the face of it, and § 313 is considered.

Fig. 2, is an enlargement of the extreme point of the Spurn, wherein the boundary line of the sand hommocks, and its relative high water line is marked with the year. The space comprehended between these two lines was a kind of flat area or fore shore over which the sea beat in rough weather; and upon which (the whole being then considered as rapidly increasing) the lower right was proposed to be built as A; Angel's lighthouse being at that time in use; and within the boundary of the firm part of the peninsula, § 345. B was the place marked out for the high light, and parallel to A B, the proposed line of direction, at the distance of 22 yards to north-westward, were C two points, C D marked out for the temporary lights; but for reasons that appear before their erection, the point C was in reality carried to E. F, a low building, containing two cottages for the temporary light-keepers, was erected at the same time. When the lighthouse was begun in 1771, the high-water line was as marked for that year. For reasons, § 336, the low light marked at A was placed at G. The high lighthouse was begun the latter end of the year 1772, and placed at H, § 346. In 1773 the high water line was as marked, and the boundary of the sand hommocks remained nearly the same for some time; but a great storm in January 1776 varied the high water line, as marked for that year, and described § 338. After this there was little variation of that line to the conclusion of the work in 1777.

On visiting the Spurn in 1786, the high water line ran as described for that year, approaching near to the low light machine at Q.—I K L, Fig. 1, is the high water line, and M N O that of low water, from which it will appear, that the Spurn Point marked P, is advanced considerably to south-westward from the line of direction, and has considerably retreated to north-westward, or nearer abreast of the high light.—Of the island R there were no traces in 1777. It was being grown with the best grass the sand hommocks had established themselves, and round the surface irregular.—It appears that little change has happened near the high lighthouses, but that the breadth of sand was there increased.

PLATE, No. 21. Section of the high light, as in the Spurn Point, to the water, such as the light is.

A A The level of the pavement of the circular court-yard.—B the coal vault.—C is a room for the smith's shop, and machine for hoisting the coals. D is a vacant room.—E, the dryer room, having two opposite fire places, to be used as the wind suits.—F and G upper chambers. H the pipe room; wherein I K, are two sets of eight air pipes, that convey air from the external hopper-

mouths, to L the receptacle; which is lined with thick plate iron; the bottom being stone.—W when the door is shut, the air ascends through the large funnel M, and the hearth N, to the fire grate, § 349.—The flame is seen in every direction through the windows of the lantern, and the smoke is collected in passing the dragon conical roof, composed of ten Elland-edge flag stones; and lastly, through the copper funnel at O. The coals in the day-time are drawn up in a tub from the coal vault, through the opening P, by means of the roll, wheel, pulley, and winch at Q. A rope, from thence ascending through all the floors, goes over a large pulley, suspended from the roof; and thence downward through the hole in the arch at R, goes down the large square wooden pipe S T, which terminates at T in an hopper-mouth proper for receiving in the bucket, &c.

The ashes and hot cinders passing through the grate, fall into the bottom of the receptacle L; and by beating the air therein, promotes a sufficient draught in the coldest weather; and which can be augmented and regulated, when there is a breeze; as any of the air pipes can be raised at pleasure.—Every morning when the receptacle is to be cleared, the ashes and cinders are thrown into the little hopper at V, and are conveyed down the square wood pipe V W, through W X, a pipe formed in the brick work, and from thence into a bung-stick in the court-yard.

The corner pillars of the lantern are of cast iron, framed in a similar manner to what has been described for the Edystone, allowing for difference in size and proportion. The ash frames are of oak.  $\gamma \gamma$  Air holes in the lantern, occasionally closed with a slider.  $z z$  Open holes in the coal vault to admit air and light. N. B. In 1785, this building was not sensibly out of upright.

PLATE, No. 22. Plan of the different floors, as applied to the purpose of the lantern.

Fig. 1, the ground plan. The outward circle, close piling. The stones in the interspaces of the bearing piles, were large Elland-edge paving stones, 19 inches depth, driven hard down, after the piling was done, with an heavy two men's paviers rammer; intruded, exclusive of the piling, to condense and consolidate the whole body of sand under the building, that the whole mass might settle together.

Fig. 2, an horizontal section of the coal vault. Wherein A is the circular stair from the entry door to the stone floor of the first room.—B a door into the coal vault; C and D the places of two hatchways, or openings through the vault. E W N S, mark the cardinal points in all the figures, and also the places of the air holes of the vault in this.

Fig. 3, the plan of the stone floor over the coal vault. Wherein, A the landing of the stairs.—B An out door, having a gublet for hoisting the coals to the stone floor, for their deposition after the lower door is blocked up. C An hatchway in the middle for the equal distribution of the coals.—D The hatchway for the coal tubs.—E The roll, wheel, pulley, and winch.—At E W N, are three windows; at S, is the gublet marked by dotted lines. F is the ash pipe.

Fig. 4, shows the framing of the dwelling room floor. The place of the windows in this, as in all the rest, conform to the cardinal points.—G H The fire places.—I The opening for the step ladder.—D The coal pipe.—J The ash pipe. Besides this, there are four more under floors, of similar construction; the girders lying alternately K, and W, and N, and S.

Fig. 5, an horizontal section of the pipe room, air pipes, and receptacle; K is one of the air pipes, their hopper mouths being shown at I.—One of the others is shown in flat at M, as applied at N, which is the section of its groove. Each pipe having one, they can be regulated according to the quarter and strength of the wind.—D The coal pipe.

Fig. 6, Plan of the lantern and balcony floor, ready for the reception of the iron work. The largest circular circle shows the circumference of the top of the brick shaft of the main column. A The balcony door.—B The hearth.—C The fire grate.—D The falling doors closing the top of the coal pipe; and E the falling doors closing the top of the man-hole, to which the ascent is by a ladder from the pipe room.

Fig. 7, is the plan, and Fig. 8, the section of the fire grate to an enlarged scale.—It is chiefly of cast iron; the bottom made to take out. A, B circular bricks, of fire clay.

PLATE, No. 23. Elevation of the high Lighthouse, and of the Scope for exhibiting the Low Light, upon Spurn Point.

These structures are supposed to be viewed upon the line of direction, in which case the hearth of the machine would have fallen directly upon the lighthouse. The line of view is marked in Plate 24, Fig. 6, being  $\frac{1}{2}$  upon a bearing of N. W. by W.  $\frac{1}{2}$  W, in which position the two structures are levelled off each other; and, to bring them into one plate, the scale is only half the size of the two former.—A person standing in the entry door of the lighthouse, will see the low light machine, or scope, through the door of the court-yard wall; which is a circle of 90 feet diameter.

The scope, including the walls wherein it stands, exhibits the light at the height of 56 feet. The fire basket of iron turning upon an axis, always places itself level, in every position of the mast A B. This loaded with a weight at A, counterbalances the iron work and fuel at top, the whole being steadied, and clipped into an iron frame, that turns in equilibrium upon the horizontal axis  $a b$ ; supported by pillars, and braces, as per figure.—When the fire wants renewal, the attendant layug hold of one of the handles of the roll  $c d$ , turns it round, so as to wind the rope shown at  $e$  upon it. This rope, after going obliquely towards the ground, passes a pulley in a stud, fixed therein, at some yards distance; and thence arising obliquely upwards, as  $f g$ , it lays hold of the mast by a small chain. By the motion of the roll the fire basket is brought to the ground, where it is fed with a shovelful or two of coals. While the rope is winding upon the roll, the rope  $h$  being coiled thereon the contrary way, was unwinding; and this being attached at A to the extreme of the lower end of the mast, and at equal distance, in rising it carries the rope along with it. The fuel being renewed, the winch is turned the contrary way round; by which, that end of the mast is brought down, and the fire basket carried up, into the position shown in the figure. The lower end of the mast is steadied against the cross piece  $i k$ ; the roll being then fastened.—The projecting part  $l$  is a small umbrell of sheet iron, serving to throw off the falling cinders from the rope.

N. B. The whole operation can be performed in a couple of minutes.

## POSTSCRIPT.

IN the preceding references it is mentioned, in the explanation of Plate No. 17, Fig. 14, that the compound purchase, called the runner and tackle; which consists of one large pulley or sheave in the runner block; and which together with a pair of tackle blocks, of three pulleys in each; that altogether consist of seven sheaves; composes a purchase equivalent to that of the great blocks; which consisting of six sheaves each, makes the whole number twelve; this last, therefore, having a greater number of moving parts, and flexures of the reeving rope; being consequently less simple, and attended with more friction; it will naturally be enquired, by those of my readers who are not seamen, or versed in the mechanic powers, why the runner and tackle is not to be preferred in all cases?

The runner and tackle doubtless, working with less friction, is to be preferred wherever it can be properly applied; but many are the cases, in which it cannot be applied: for, it will readily be perceived, by inspection of Fig. 14, that while the tackle blocks L, M, are hauled together, or brought block and block; and one of them has moved through the space LM; the runner block K will only rise, or move, through half that space, on account of the runner rope being double. It therefore follows, that the weight can be lifted or moved only half the height or space, where a runner is applied, that it could be where the tackle alone is applied. In consequence, if a weight was to be lifted upon shears by the runner and tackle, to a given height, the shears would be obliged to be twice as high; which would in most cases be very inconvenient; but where there is height enough; or in the case of a guy-rope or guide rope, as in Fig. 6, marked 6, 7, there being a considerable length of dead rope, not engaged with any sheave; the runner may be of any length, to give the purchase the scope required.—The runner, therefore, though it doubles the purchase of the tackle blocks, it reduces the height to which the weight could be hoisted by them alone, to half.—I shall conclude with observing, that if the great purchase blocks of 20 sheaves (Plate No. 18, Fig. 1. and 2.) were worked with a runner, they would form a purchase of forty to one, and, of the size of blocks described, would with security hoist a weight of 90 tons.

THE END.







# MAP of the COASTS & COUNTRY opposite the EDESTONE ROCKS.

Nº 2



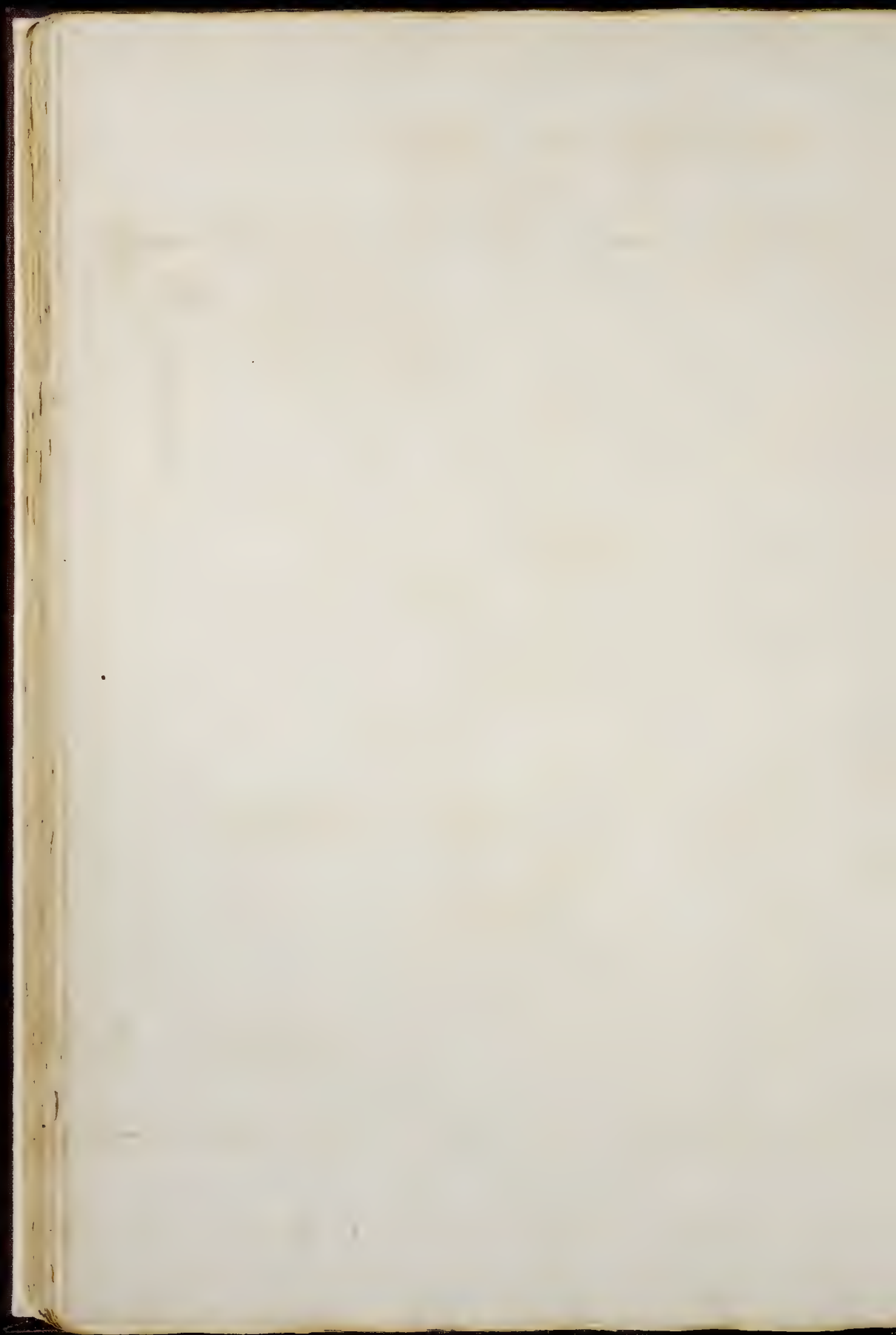
1. the small shoals at the FLY STONE Rocks to render them Evident  
the more dangerous are shown within the rest they  
would be to the Sails of the Ship  
2. the River Plym  
3. the River Tavy  
4. the South Reef  
5. the South Point or Ledge  
6. the North Point or Ledge  
7. the Nymphaeum Bay

1. Lettered thus a topographical plan of  
PLYMOUTH Sound & Harbour & Bay  
2. Map of CORNWALL & other Observations

Measures of Lengths, Areas & Volumes in French & English

Printed by W. B. PEARCE, Stationer & Printer, in the Strand





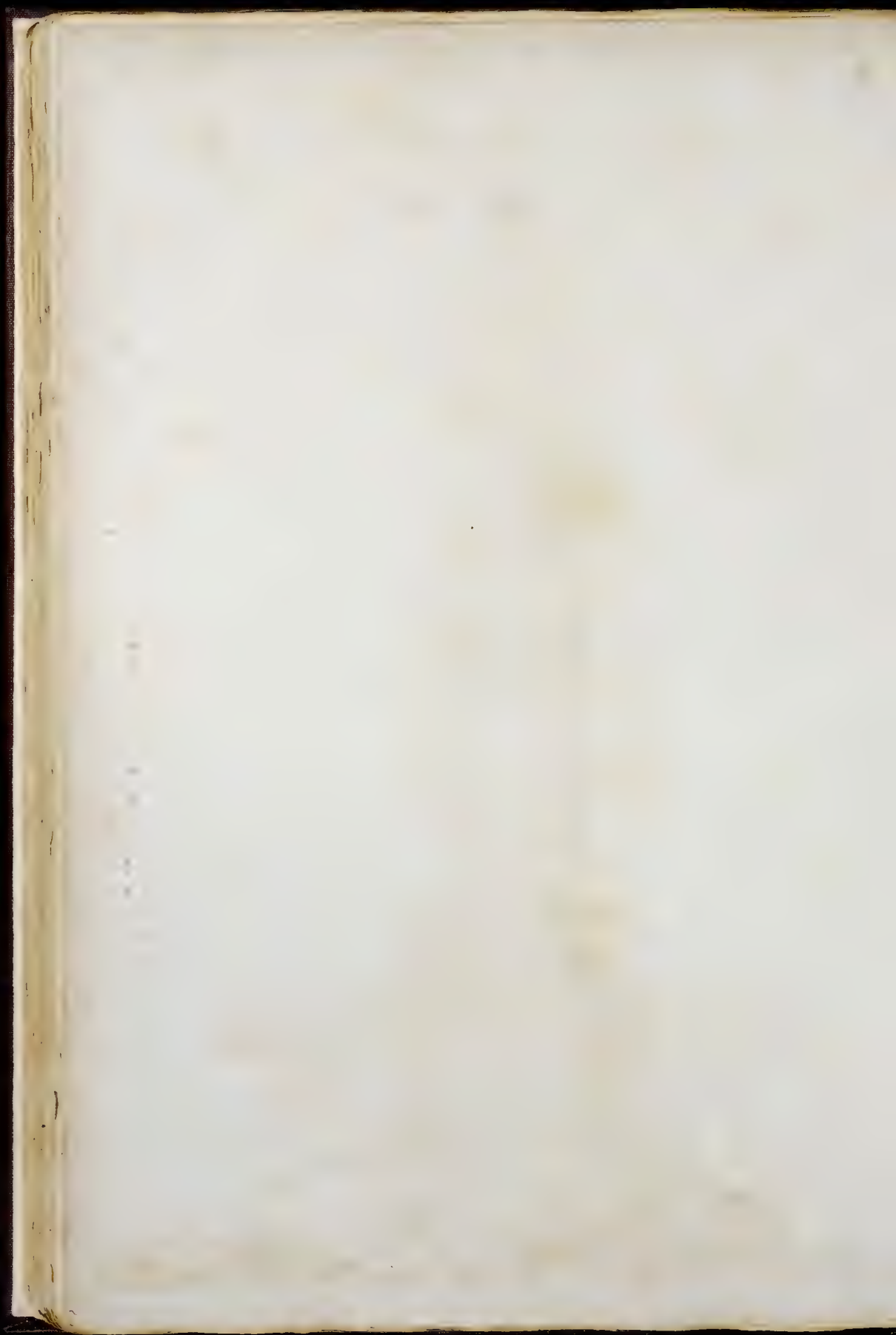








South ELEVATION of the ORIGINAL LIGHTHOUSE,  
 Built upon the EDDYSTONE ROCK, according to the first Design of MR WINSLOW KEY.  
 Taken from a Perspective Print drawn at the Rock by James Gill Johnstone Painter 1754.



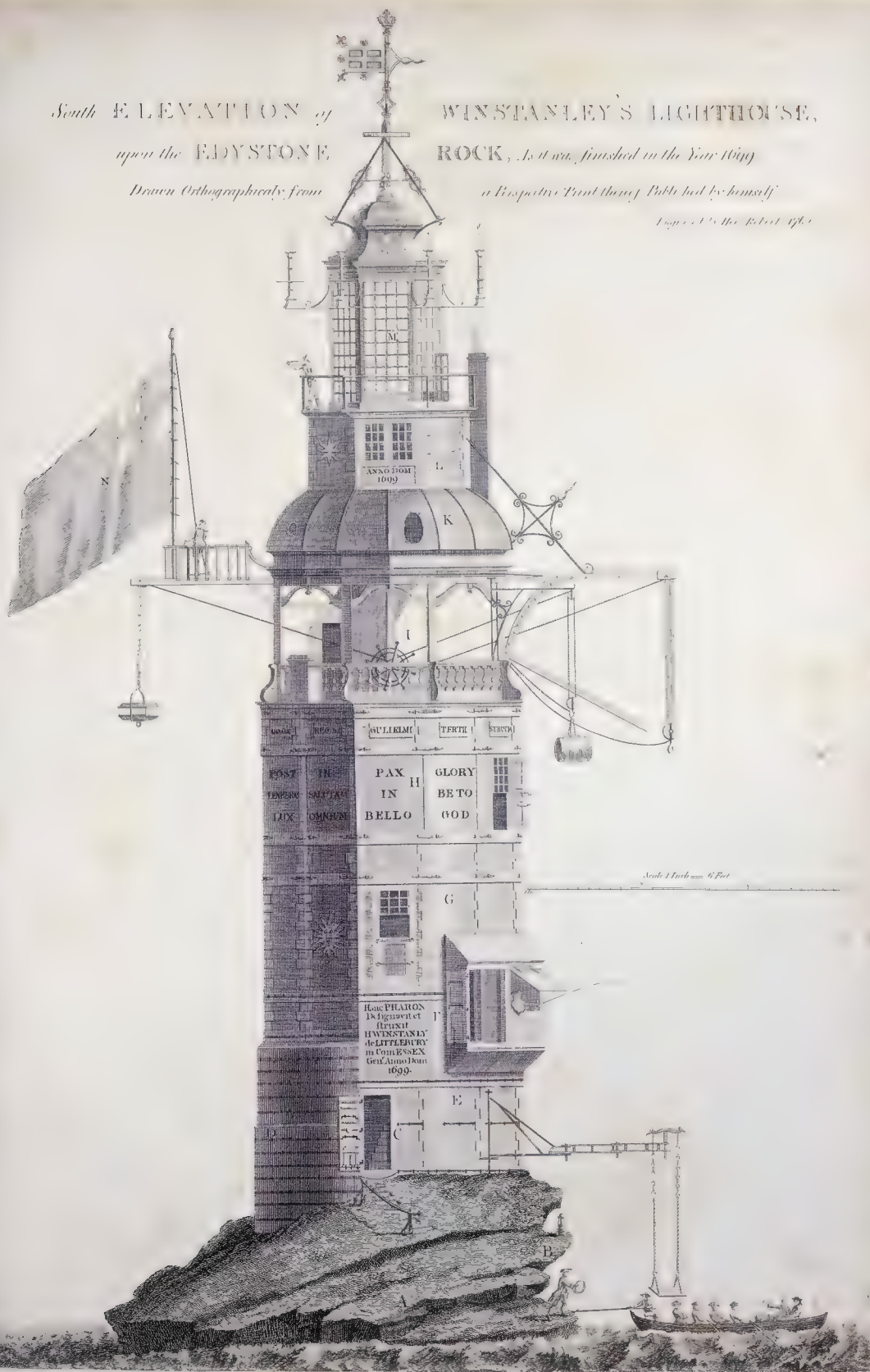
South ELEVATION of  
upon the ELDYSTONE

WINSTANLEY'S LIGHTHOUSE,  
ROCK, As it was finished in the Year 1699

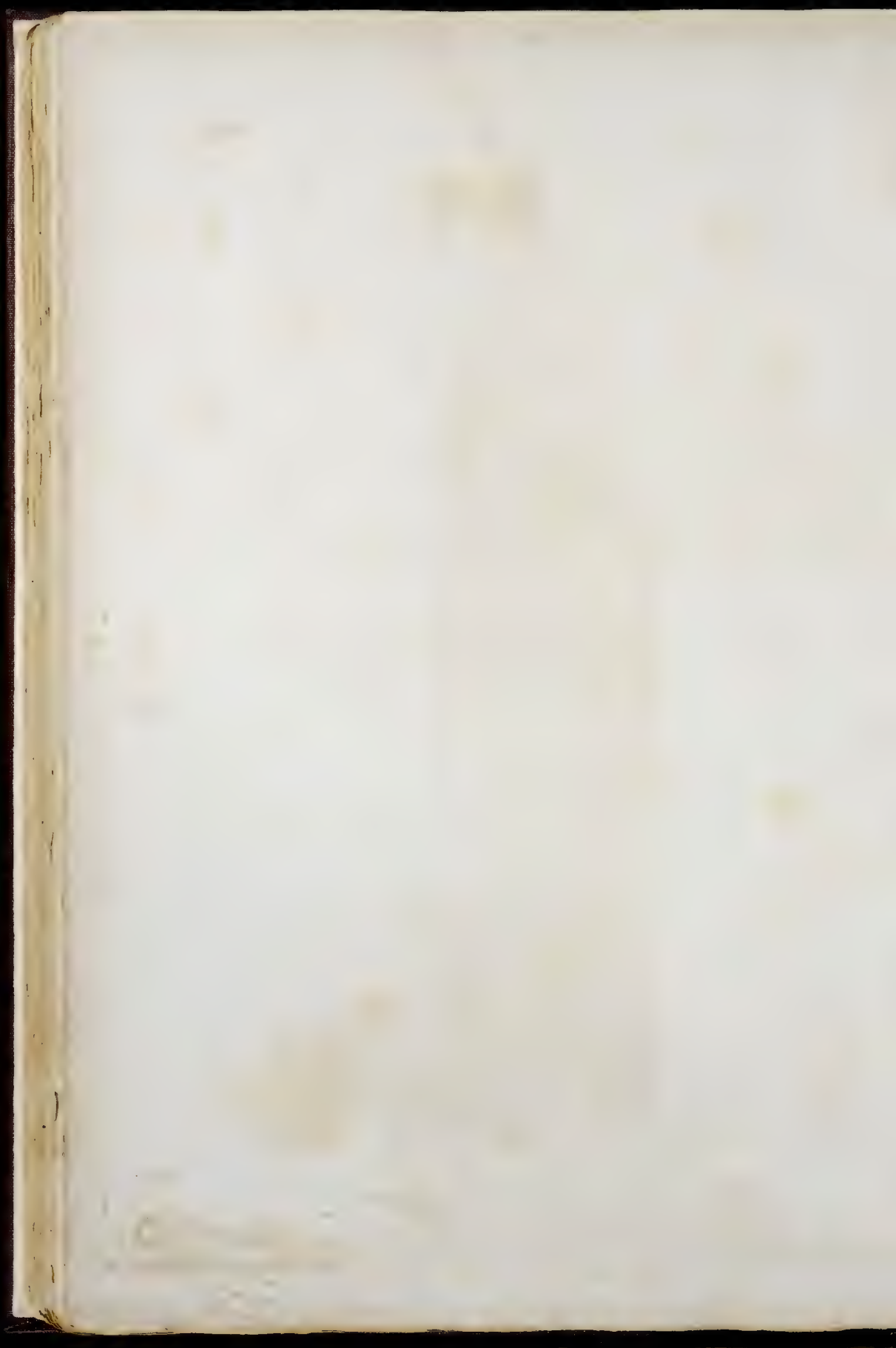
Drawn Orthographically from

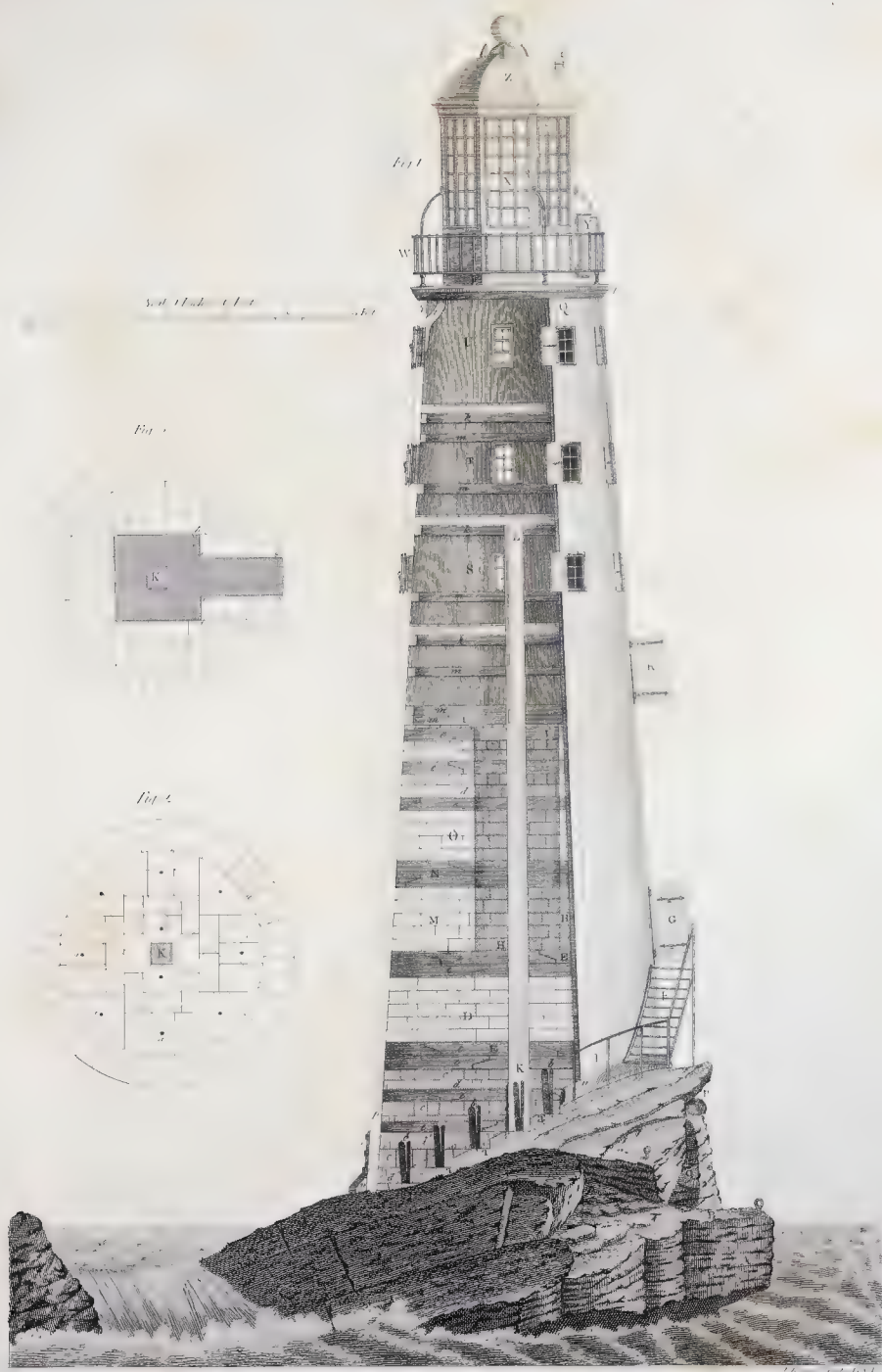
a Perspective View thereof Published by himself

Designed by the Architect





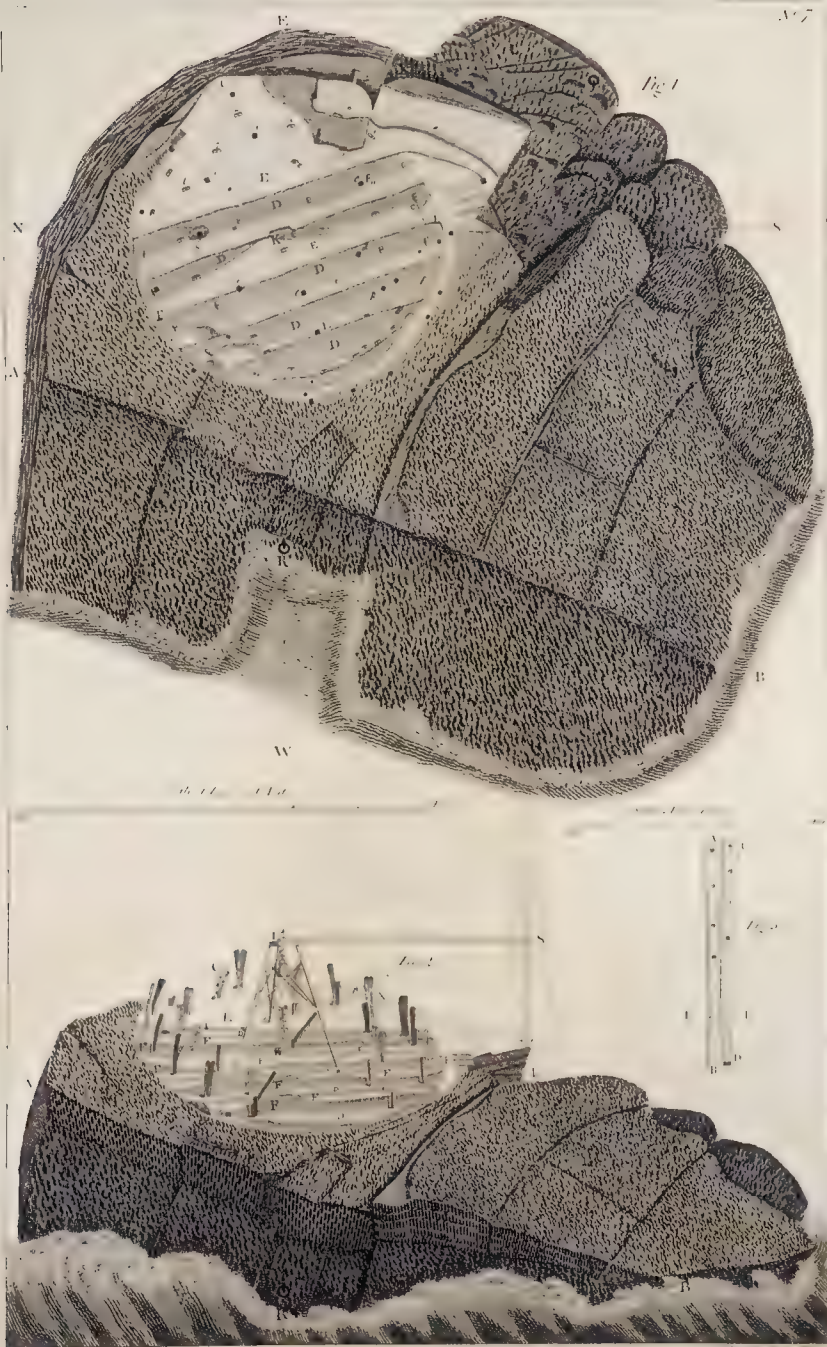




South ELEVATION & SECTION of RUDYER'S LIGHTHOUSE,  
*as plotted in 1749, represented as it stood previous to its destruction by fire in the Year 1755.*







PLAN and perspective ELEVATION of the EDYSTONE ROCK,

*Seen from the West Taken from the Model there mentioned Sect. No. 5*





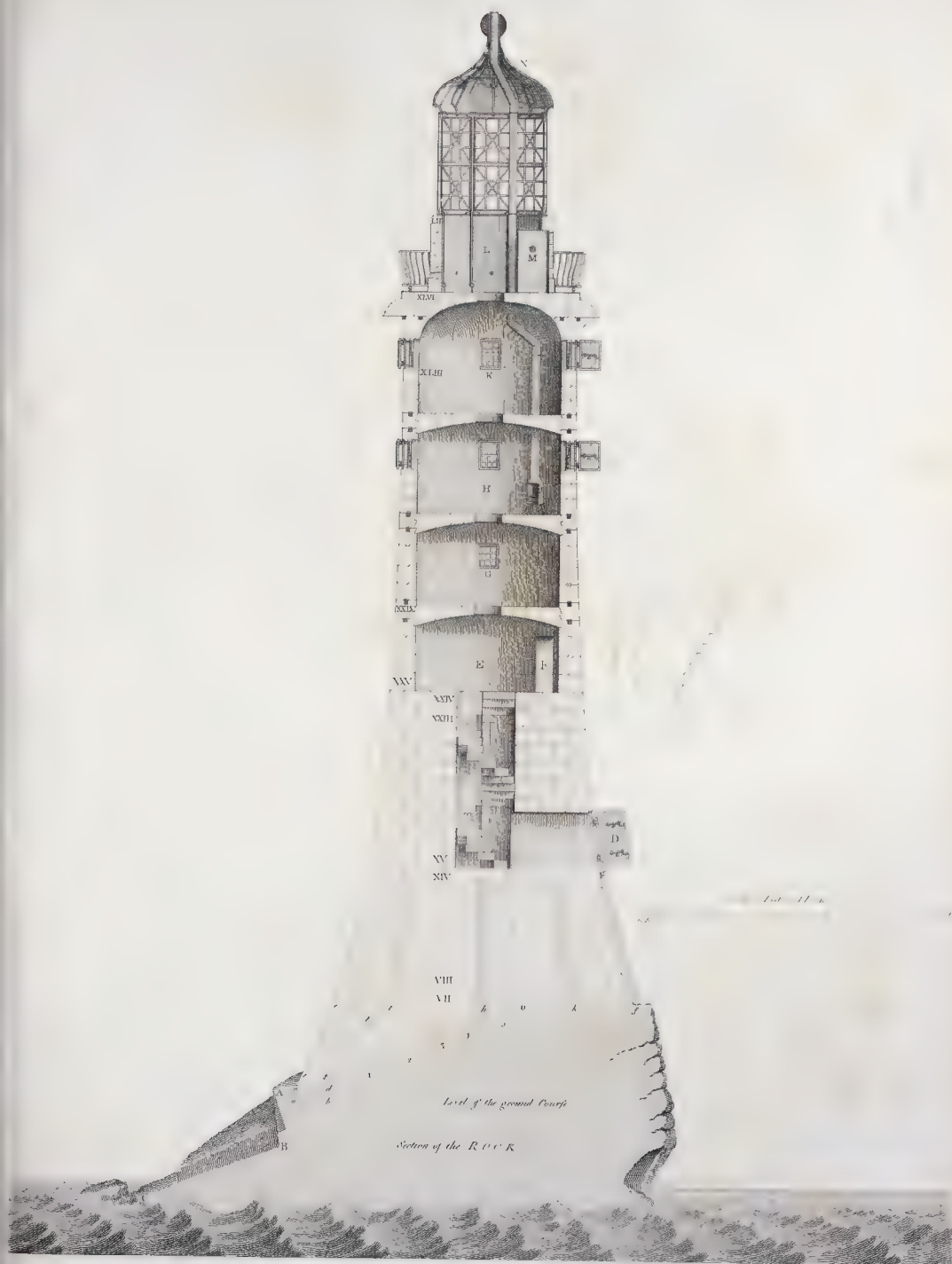
South ELEVATION of the STONE LIGHTHOUSE, completed upon the EDYSTONE in 1759.

Shewing the Prospect of the nearest Land, as it appears from the Rocks in a clear calm Day.

1. is said to be the Year 1759. W. P. L. is the name of the painter.







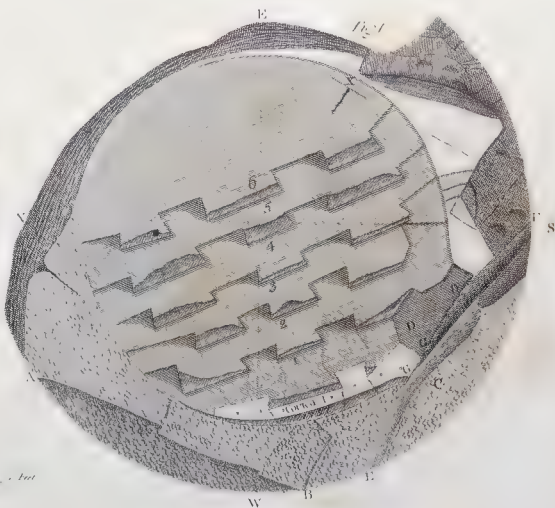
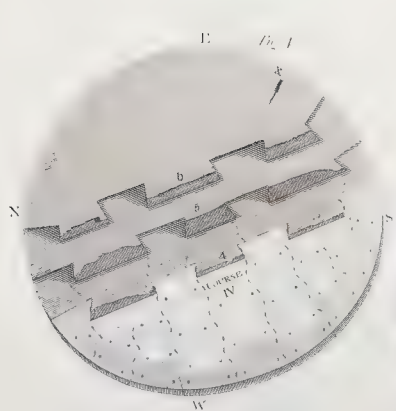
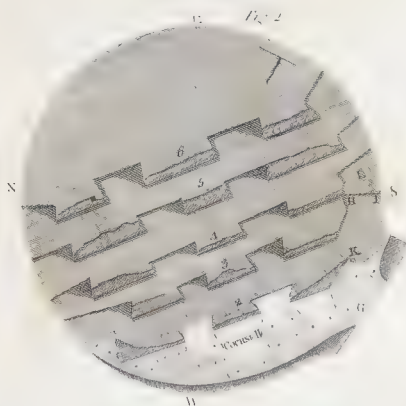
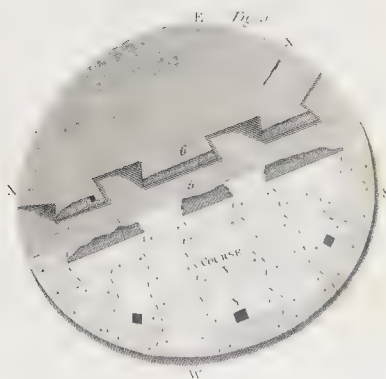
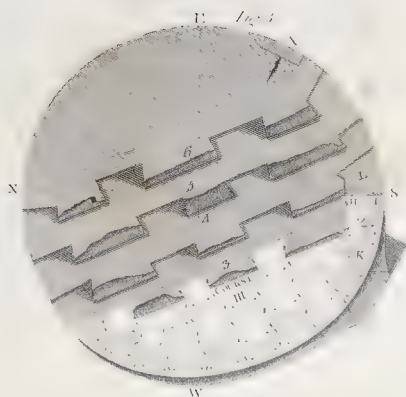
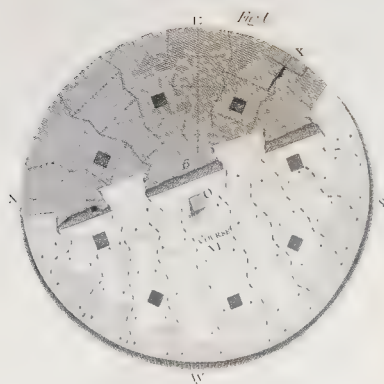
SECTION of the EDYSTONE LIGHTHOUSE upon the E & W Line as relative to N & S

a Survey taken of the same by J. W. WADSWORTH in 1811

1811





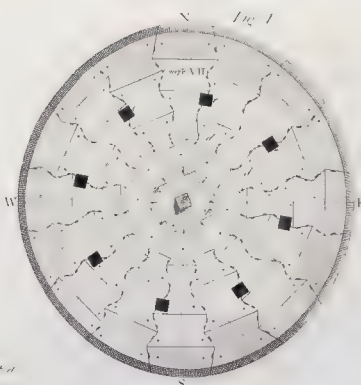
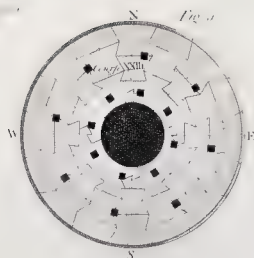
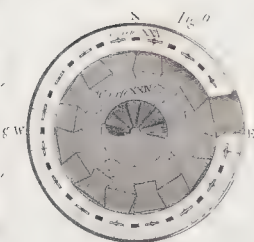
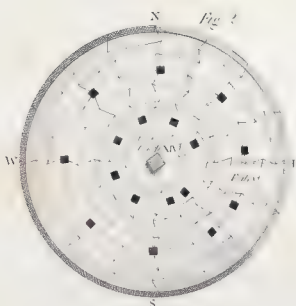
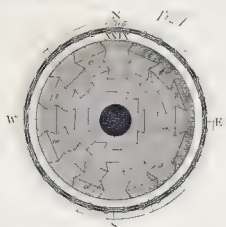
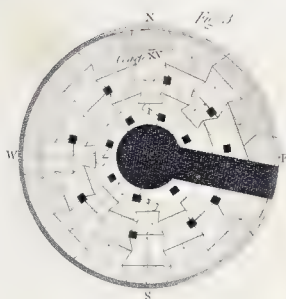
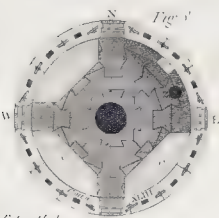
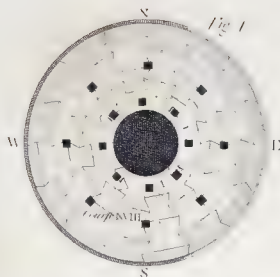
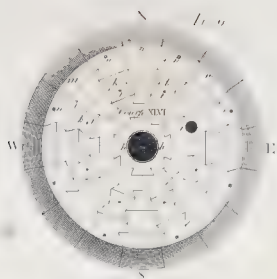


Scale of Feet—One Inch

PLANS of the ROCK sheltering out, & prepared to receive the STONE BUILDING.  
Showing the SEA FOUNDATION COURSES.

J. R. and J. G. 1786





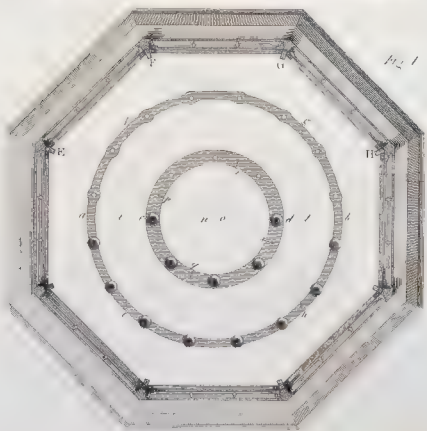
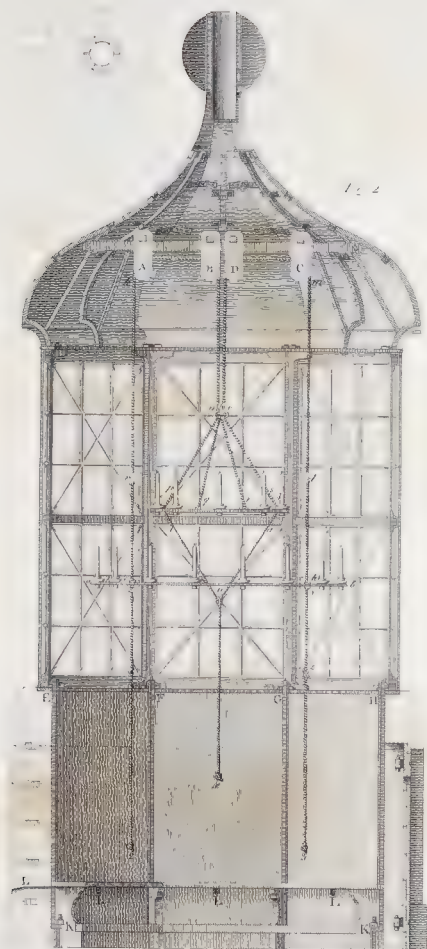
Scale of Feet

PLANS of all the Different COURSES from the Top of the ROCK to the Top of the BALCONY FLOOR inclusive

11







*An enlarged* HORIZONTAL & VERTICAL SECTION of the EDYSTONE LANTERN;  
with the CHANDELIERS.

*Engraved by the Rev. J. M. Edwards.*







Fig. 6

Scale 12 Feet = 1 Inch

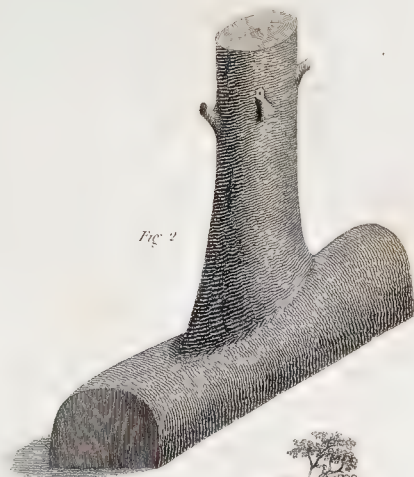


Fig. 2



Fig. 1

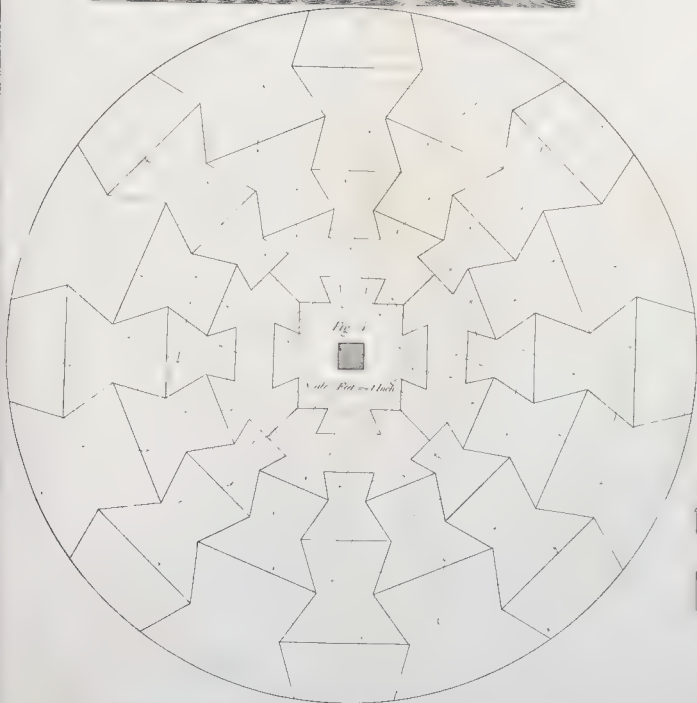


Fig. 4

Scale 12 Feet = 1 Inch



Fig. 5



Fig. 6

Original IDEAS, HINTS, & SKETCHES, from whence the FORM of the PRESENT BUILDING was taken.





A View of the ROCK on the EAST SIDE, and of the WORK advanced to Course XV. being the first of the ENTRY COURSES,  
 Showing the manner of LANDING and HOISTING the STONES in every Stage of the BUILDING.

Engraved by M. R. B. 1784.

Printed by J. D. 1784.





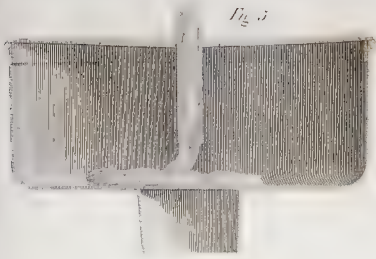


Fig. 3.

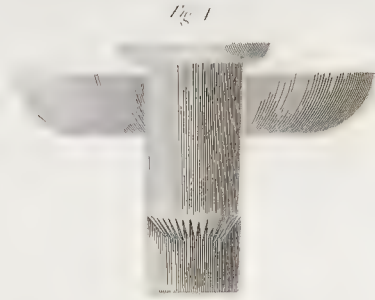


Fig. 1.



Fig. 2.

Y

X

Fig. 2.

same to the first part. In the middle of the

Q

F

E

R

G

E

F

D

B

D

D

N

Fig. 1.

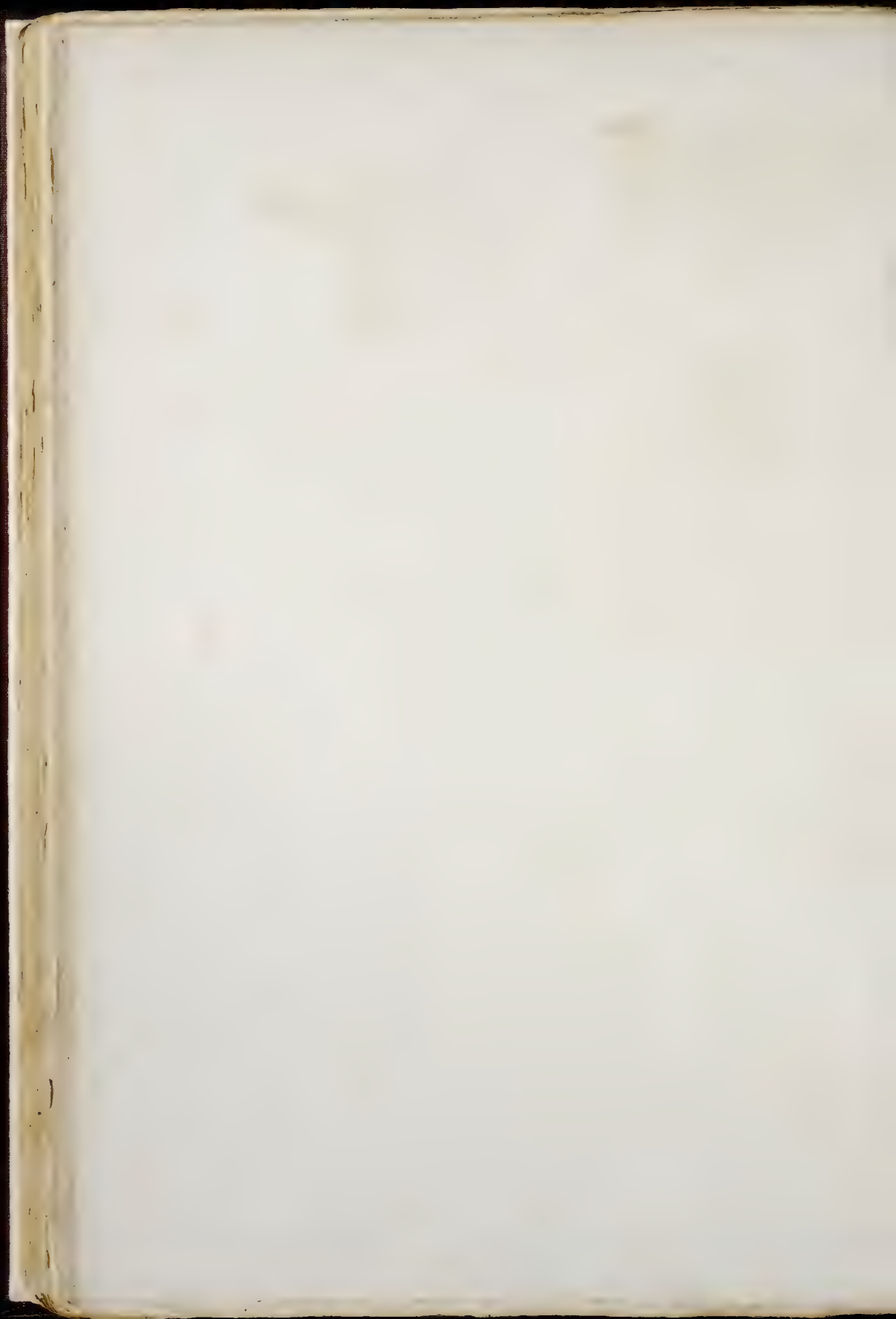


G

D

EXPLANATORY SKETCHES of Particular Parts comprehended in the foregoing GENERAL DESCRIPTIONS.

J. ROSS





N. 16.



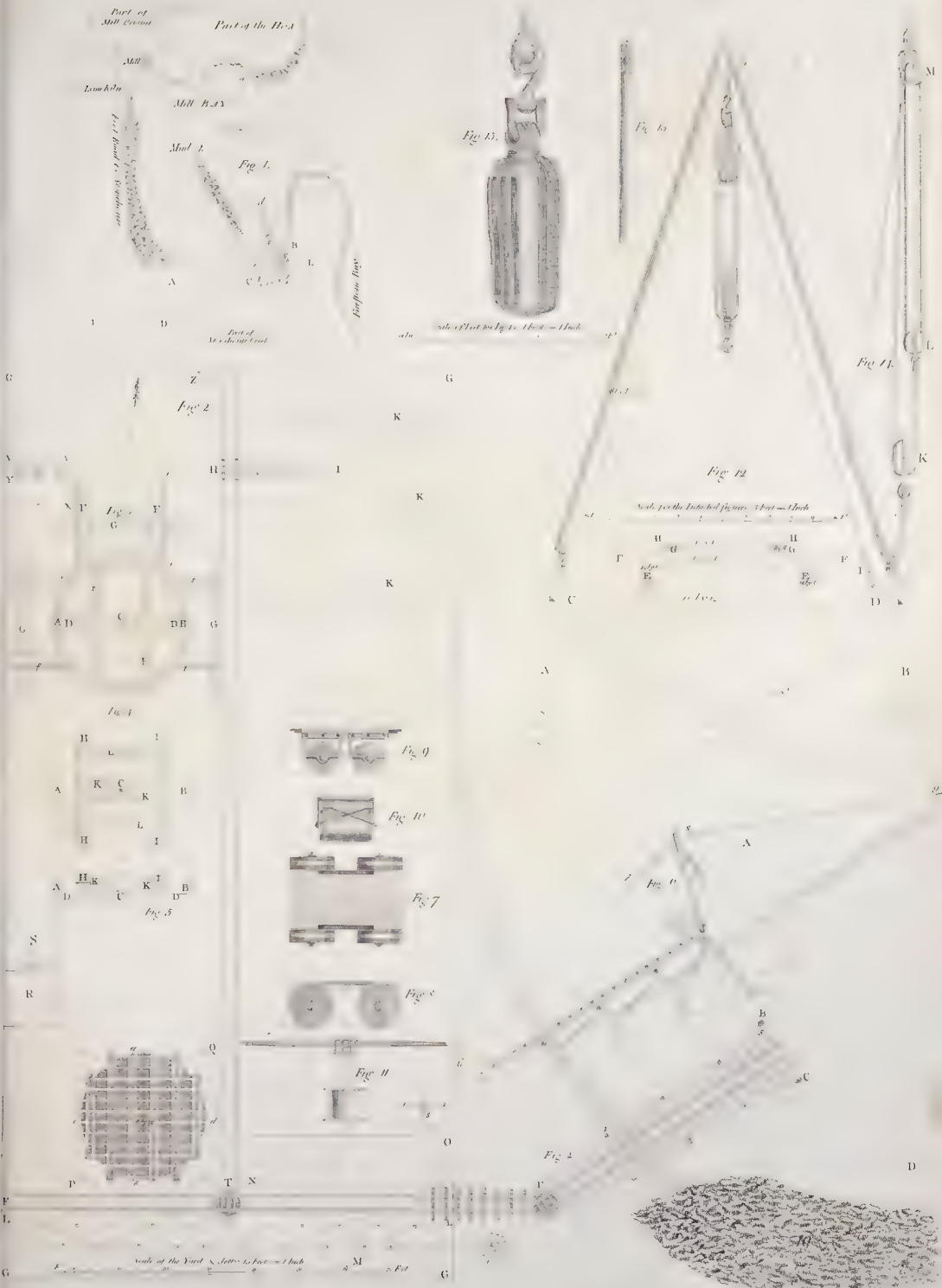
South of Gate

N. 16.

MR JESSOP'S DRAUGHT by which the YARDS were built for the EDYSTONE SERVICE.

J. Jessop Esq 1856

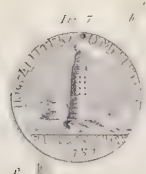
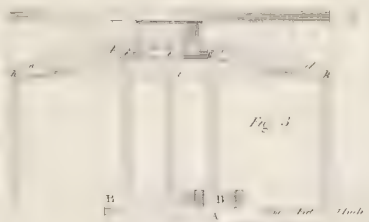
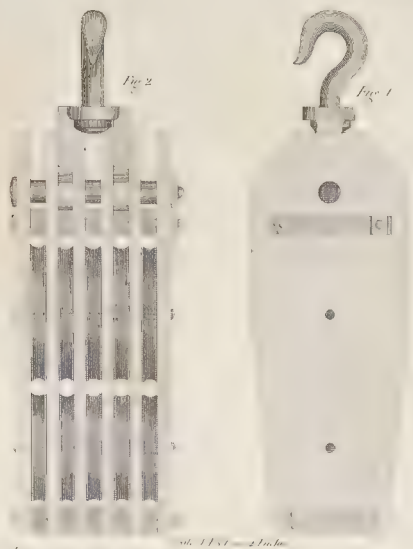




PLAN & DESCRIPTION of the WORK YARD at MILL-BAY with its FURNITURE & UTENSILS. A. Rev. of Jan. 1795







	$D$	$m$	$\epsilon$
EW	1	1.7	1.68
EW	2	1.7	1.7
EW	3	1.7	1.7
(a)	1	1.7	1.68
EW	1	1.7	1.7
EW	2	1.7	1.7
EW	3	1.7	1.7
SWP	1	1.7	1.7
SWP	2	1.7	1.7
SWP	3	1.7	1.7
WMP	1	1.7	1.7
WMP	2	1.7	1.7
WMP	3	1.7	1.7

WME — 46.6  
 MWE — 7.7  
 GWF — 0.52  
 FGW — 42.50  
 FW — 0.43  
 FWI — 0.4  
 NFI — 0.4









# PLAN of the SPURN POINT, as in 1780. Also its Variations during the preceeding 20 Years.





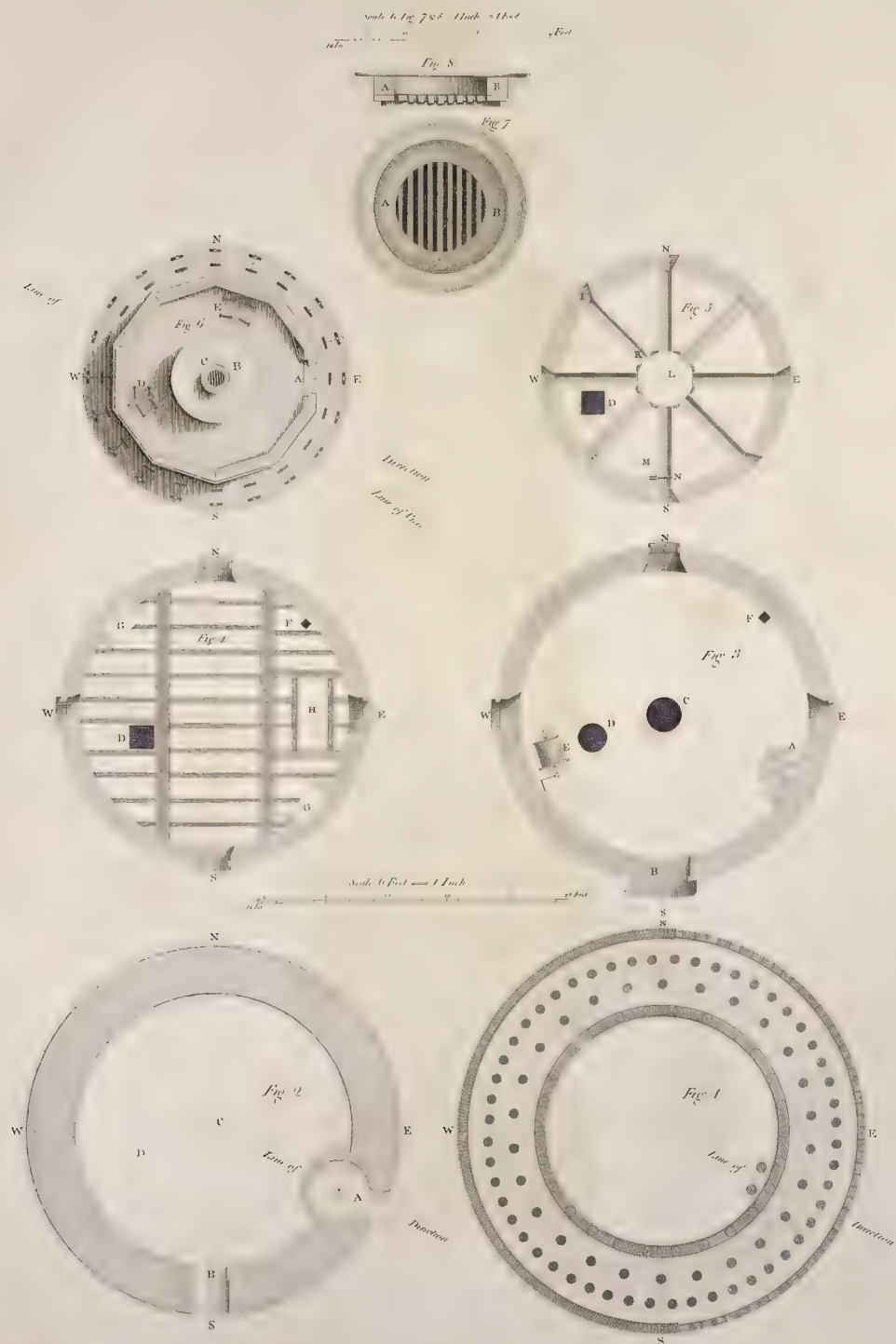




SECTION of the HIGH LIGHTHOUSE upon the SPURN POINT. *J. Record sculp. 1781*







PLANS of the different FLOORS applicable to the preceding SECTION.





ELEVATION of the HIGH LIGHTHOUSE upon the SPURN POINT, & of the SWAYPE, which the LOW LIGHT is Lighthouse

1831











